Compilation of Recommendations on environmental regulations

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GEOENVI

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Executive Summary

The main objective of this report is to present a set of recommendations to harmonize environmental regulations and best practices of deep geothermal for a series of selected technical and process-related topics. The topics and the criteria adopted for their selection are described in detail in other GEOENVI reports resulting from the activity of Work Package 2 (Map environmental matters for deep geothermal energy) and Work Package 4 (Engage with decision-makers: recommendations for harmonisation of regulations)[1].

This report first describes the regulatory barriers and gaps and then proposes recommendations to overcome each topic's identified issues.

In the first place, the report addresses the four chosen ***technical topics***:

- Seismicity, i.e., the potential modification of natural seismic activity during the geothermal projects' development and operation
- Aquifers' interference, i.e., the potential connection of aquifers via the wellbore, the disturbance of non-targeted aquifers, and the modifications of reservoirs' physiochemical status;
- Aeriform emissions, i.e., the potential geothermal fluid aeriform emissions during wells' drilling and plant operation;
- Discharge of geothermal fluids, i.e., the potential chemical and temperature effects due both to discharge of geothermal water and drilling fluids onto and into surface/underground water bodies and reinjection of geothermal fluids after production.

Next, the report provides recommendations for five ***process topics***, which are not directly related to technologies but instead refer to practices that impact the development of the geothermal market and reference environmental aspects. These regulatory challenges and cross-cutting topics are:

- Complex licensing and delays;
- Environmental Impact Assessment, taking into account the nature of individual projects;
- Information sharing, including the communication of environmental data and information;
- Creating local benefits as positive impact linked to geothermal development;

[1] See Environmental regulations for deep geothermal energy and its cited documents https://www.geoenvi.eu/publications/environmental-regulations-for-deep-geothermal-energy/

- Organizing public participation in the development of geothermal projects.

All data related to the technical and process topics collected at the national level accompany the document as tables in the Annex.

Introduction

The regulatory framework is one of the most relevant issues addressed by the GEOENVI project to tackle the environmental concerns for deploying deep geothermal energy in Europe. The relevance is even more striking when prevention, mitigation, and recovery from environmental impacts and risks and authorization to the development come into play. Among the activities carried out in the project's Work Package 4, recommendations to improve environmental regulatory practice have been the main focus. A previous report, GEOENVI D4.1[2], described the collection of the essential items for the identification of legislative gaps. These items included information on environmental regulation and policies at the European, national and regional level, as well as authorization strategies and action plans. Other information for supporting the harmonisation of procedures and the transferability of best practices, such as guidelines and evaluation methodologies, data sharing, and relevant terms, have also been collected and further analysed in the occasion of the stakeholder engagement activities during policy events. These latter are described in the GEOENVI deliverable D4.4[3].
Following the recommendations for harmonizing EU level regulations (report D4.3[4]), this report provides a list of recommendations for improved regulatory practice. The recommendations here expressed do not cover all potential impacts and risks considered relevant for the geothermal development described in detail in the Deliverable D2.1 but rather focus on selected topics. Indeed, most potential impacts and risks appear generally well covered by current legislation, and practices capable of fitting established regulations are of general use. However, it was observed that some topics, perceived as particularly relevant by engaged stakeholders, are mostly governed by national or regional practices and guidelines, by Environmental Impacts Assessments (EIA), and by permitting processes and Good Practices among experienced project developers and operators. Their relevance and the high potential for sharing best practices among countries upon these topics determined their choice. For each of them, after a detailed discussion, a list of recommendations was elaborated.
This report is organized following the structure already described in deliverable D4.4. First, the four chosen ***technical topics*** are treated, describing the related regulation barriers, gaps and recommendations. The report then provides recommendations for five ***process topics***, which

[2] https://www.geoenvi.eu/publications/decision-making-process-mapping/
[3] https://www.geoenvi.eu/resources/
[4] https://www.geoenvi.eu/publications/recommendations-for-european-harmonisation-of-geothermal-environmental-regulations-in-the-eu/

are not directly related to technologies but rather refer to practices that impact the development of geothermal market and reference environmental aspects.
This document has been updated in the final stage of the project to incorporate hints from the last round of webinars organised at the European level and described in the GEOENVI report D4.4.

Ranking regulatory issues

The analysis of the environmental regulations and policies mapped in the Deliverable D4.1 has been the starting point to measure their impact on the geothermal energy market and recommend their improvement, proposing a European Geothermal Energy Guideline. Harmonization of the current rules and practices, including the Best Available Technology approach, should also be set up to avoid market distortion, in line with the aim of EU environmental legislation. The collected information was analysed to answer the following questions:

- To what extent are national legislations consistent with EU legislation? On what aspects would harmonization be required?
- Are current regulatory frameworks sufficient for mitigating the impacts and risks at hand, or possibly too strictly applied? What are the main regulatory gaps? Are these problematic?
- How are legislations applied in practice? Which informal aspects come into play?
- Which elements of national regulations and guidelines can be considered best practices that countries may share?

As described in detail in deliverable D4.4, two rounds of policy events have given the project's partners the occasion to discuss the relevant challenges for environmental regulation and social acceptance to be addressed in more detail with stakeholders of the six GEOENVI participating countries. The chosen nine topics covered were considered of particular interest by the engaged stakeholders, both for their high societal impact having the potential to raise concerns and their high potential for sharing best practices across countries.
It was observed that some technical topics required special attention:

- **Seismicity** is a crucial concern in five of the six covered GEOENVI countries, notably in Belgium and France. Only in Hungary it is considered as a minor concern. Managing

this risk is challenging due to the high uncertainty about the controlling processes, its low predictability, and its potentially high societal impacts. In the absence of definite rules, countries established a variety of guidelines for monitoring and, in some cases, thresholds, contingency plans, and traffic-light protocols. There is a potential for sharing best practices across countries.

- **Aquifers' interferences**: although well-regulated in the Water Framework Directive (Water Act[5]) and associated water quality legislation, from country-to-country the monitoring guidelines appear very different, and technical prescriptions vary. Countries may share some critical best practices on this topic.
- Air quality, including **aeriform emissions** from geothermal plants, represents an important issue for social acceptance in Iceland, Italy, and Turkey. Although EU and national air quality legislation regulate well some substances, others are missing, and monitoring parameters (e.g., emission thresholds, measuring frequency) are not harmonized. There is room for improvement and shared regulation and practice.
- An issue envisaged in most countries, and particularly in Hungary, is the **discharge of geothermal fluids**. Since there are good practices to be shared, harmonized recommendations have been considered useful.

Other topics, such as surface disturbances cited as a concern by most countries, have been considered well regulated by current legislation and were not analysed further.

Other main regulatory challenges for market up-take and issues of social acceptance emerging from workshop discussions were clustered into a series of cross-cutting process topics:

- **Complex licensing and delays**, as most countries report on long and complex licensing processes, for example in Italy, Turkey, Hungary and Iceland. Reasons for complexity may include: the involvement of multiple organizations in the licensing process (c.f. Hungary, Turkey) and/or the need for multiple licenses (c.f. Hungary).
- Matching a generic regulatory framework with the specific nature of individual deep geothermal projects (c.f. Belgium, France, Turkey) and the different environmental impacts and risks that may apply is a real challenge. The elaboration of **Environmental Impact Assessment** (EIA) practical guidelines, specific to deep geothermal projects,

[5] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

by adapting procedures to the real needs, and by fitting established regulations and business practices, are considered a priority.

- **Information sharing,** to guarantee that relevant information is shared with the general public, also to balance often inadequate information from the media and internet. It includes information about environmental topics and essential information, such as success stories and comparability of projects in attributing good or bad experiences.
- **Creating local benefits**: This may be an important trigger for social acceptance, also ensuring that geothermal narratives are more coherent with vocations of territories.
- The **organization of public participation** appears relevant to address in a period of energy transition, as for other energy technologies. Environmental aspects are relevant during the public inquiries and creation of co-designed development.

Recommendations for technical topics

There isn't a one-to-one correspondence between the four topics covered here and the potential impacts and risks identified in the GOENVI project (see deliverable D2.1 for details), as they may cover aspects of different possible impacting phenomena. E.g., *discharge of geothermal fluids* covers aspects related to "Liquid and solid effusions to surface", and "Pressure, thermal and flow changes", and *aeriform emission*s refers to both "Degassing" and "Blow out".

For each topic, information has been collected and organized using templates that have been filled for the relevant countries. They are available in the Annex.

Seismicity

Modification of natural seismic activity during a deep geothermal project's initial development and operation can be a concern for regulatory authorities and communities. The evidence of geothermal plants in operation indicates that this is, however, generally not an issue. Indeed, most of the geothermal plants in Europe, and after many years (amounting to decades for Italian, Icelandic, and French-Paris Basin plants) of operation, did not create problems related to seismicity. Nevertheless, there have been a few exceptions. As these isolated incidents could generate public misconceptions, it is essential to ensure robust response mechanisms.

Besides rules establishing general protection of territories and infrastructures, liability, and contingency plans, seismic adverse effect is mitigated mainly by applying best practices and guidelines.

Fig. 1 synthetises the situation in the countries mapped in the GEOENVI analysis, which includes some of the participating countries to the GEOENVI consortium, Switzerland and Palatinate region in Germany, in view of the seismicity concern of some projects in these areas. More details on the collected data can be found in the Annex, Seismicity template.

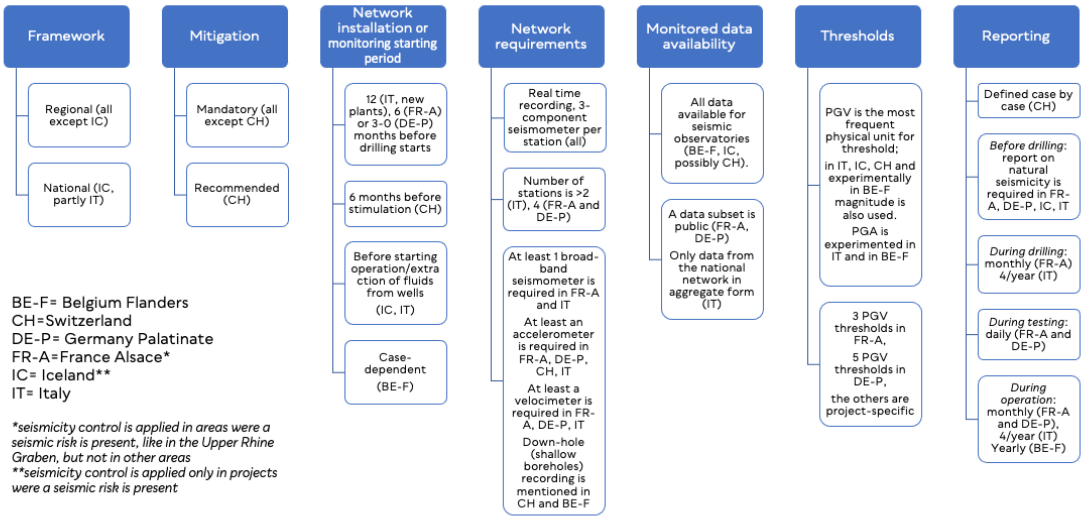

Figure 1 Diagram showing in synthesis how regulations and solutions for safety issues are established at the national level in the GEOENVI participating countries to mitigate the potential modification of natural seismic activity.

The collected data analysis showed that real-time data monitoring is required in all the countries mapped in the analysis except Iceland, where it is required only on selected cases, depending on circumstances. Monitoring practices show, however, some differences:

- The time of installation of the monitoring network is variable: 12 months (Italy new plants), 6 months (France -Alsace) or 3 months (Germany-Palatinate) before drilling starts; 6 months before stimulation in Switzerland; before operation in Iceland and Italy;
- The minimum number of stations and details are variable;
- The number (3 in France- Alsace, 5 in Germany-Palatinate, project- or region-specific in others) and threshold values vary;
- Data availability varies among countries, as does the frequency of reporting to the authorities.

Recommendations

1. Providing a comprehensive description of the status of seismicity in the developed geothermal areas

Creating a list of all geothermal plants, the duration of their operation, and an history of noted seismic events in the area will help to clarify the level of the effects. The operational parameters increasing the seismicity and ways to handle it in geothermal should be described. Such a document will provide correct information and great transparency for the public and administrations.

2. Establishing a European code of best practices for seismicity monitoring and control

Our recommendation is to establish a European code setting-up a sequence of actions to assess, monitor, and handle the seismicity potentially connected to geothermal projects. The topic is covered in some regions or countries, but not at a European level. A harmonization is hardly possible without an extensive and detailed study of existing practices. It is important to clarify that rule should be flexible and account for different geological and technical conditions. Topics that are site/geological basin specific and those relevant at the European level should be distinguished. Otherwise, there is the probability of jeopardising the geothermal projects where the seismic adverse effect is minimal, as is the case in most plants.

The process to establish this Code must be transparent and participatory, including mining authorities, experts in seismicity and civil engineering, experts in geothermal, oil &gas, mining industry, and civil society. A preliminary list of the actions the Code should consider is included in the **green box below**.

3. Harmonising guidelines and application of the European code to all reference sectors

Since seismicity relates to different sectors associated with the subsurface activities (e.g., geothermal, oil & gas, waste disposal, mining), it is necessary to have a consistent set of rules among industries.

4. Ensuring access to data on seismicity

Transparency of monitoring and operational data of reference, with diversified level of access for administrative, scientific and public recipients, is crucial for this topic.

Main recommended actions the code should consider

- Describe good practices for fluid production, injection or reinjection to be adopted (flow rate, reservoir overpressure, reservoir temperature and geology, location, etc.);
- Prescribe seismic hazard analysis, based on available data;
- Define thresholds to identify the level of hazard and risk and a) exclude projects of low hazard from further actions, b) establish further actions based on the levels of hazard or risk.

Further actions to be considered in case of hazard:

- Define contingency plans, respecting local liability regulation;
- Conduct and regularly update predictive modelling with available data (e.g., slip and dilation tendency if regional stress regime is known, orientation of faults by seismic reflection data in some geological context);
- Define a seismic velocity model for the project and the layout of a suitable monitoring network, install it, and control that it remains operative;
- Conduct seismic baseline (natural background seismic level before operation) measurements with an installed local network or use data from an existing seismometer network for at least 6 -12 month before drilling or stimulation or operation;

Once wells are available:

- Update the seismic velocity model performing sonic log or Vertical Seismic profile or check shot (standard in shallow oil and gas well, but not in deep wells);
- Update predictive modelling (flow-temperature-mechanical models of the geothermal system) of reservoir and surface installations to define the preferred operating window of the geothermal plant and preferred plant design (such as measures to be taken to avoid stress-shocks (flow, temperature or gas-related), positioning of sensors, and well design;
- Conduct stress-strain analyses on the wells; refine reservoir model, redo the seismic risk analysis if needed; if enough events are recorded, assess the Gutenberg-Richter law associated to local seismicity to assess the presence of structures nearby;
- Set-up a control system, e.g., a traffic light system (TLS) based on (quasi)real-time signal processing, correlation of events with production data and forward modelling. It should be operated solely by skilled and trained staff;
- Adapt preliminary thresholds for further actions. Depending on the hazard analysis, the control system may either be required for the entire lifetime of the geothermal system or limited to certain project phases;
- Evaluate the seismic activity at given points in time (e.g., after an event flagging a threshold's pass; after 12 months of operation; during shut-down for workovers/maintenance) and adapt the monitoring/control if needed. During all operation phases, update the Gutenberg-Richter law associated with the local seismicity.

Aquifers' interferences and physical disturbances

This aspect covers the legal framework to mitigate **potential** connection of non-targeted aquifers *via* the wellbore, and modifications of reservoirs' physical and chemical status due to extraction of geothermal fluids.

The European regulation for water protection (Water Act[5]) and its national implementations cover almost all issues related to this topic, including minimization of water amount. However, water management practises may differ in the Member States.

Fig. 2 synthetises the situation in the countries mapped in the GEOENVI studies. More details on the collected data can be found in the Annex, Aquifers' interferences template.

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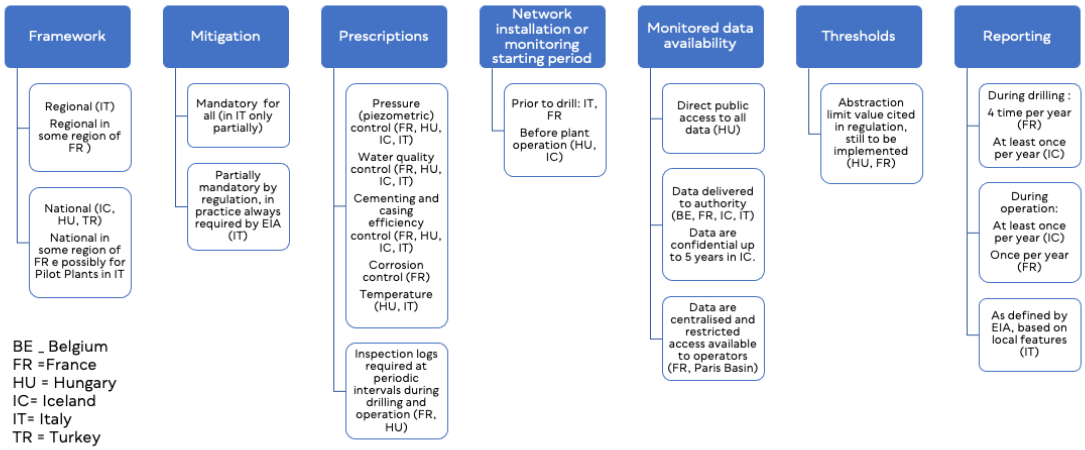

Figure 2 Diagram showing in synthesis how regulations and solutions for safety issues are established at the national level in the GEOENVI participating countries to mitigate the potential impacts of aquifers' interferences.

The analysis of the collected data showed several similarities:

- All countries, except Turkey where aquifers are only mapped, require a plan for excluding interference with non-targeted aquifers during drilling;
- Pressure and groundwater quality control and cementation inspection are explicitly required in France, Hungary, Iceland, and Italy;
- Very detailed prescriptions are required in France, Hungary, and Iceland;
- A code of good practices for drilling is available in Flanders in Belgium, France, Italy. In most cases, the good practice codes are suited for shallow groundwater wells but are not well adapted for deep geothermal wells.

There are, however, also many differences:

- Flanders (Belgium) adopts prescriptions only for the drilling phase;
- Corrosion control is required only in France and partly in Italy; temperature control is required only in Hungary and partly in Italy;
- The concept of "abstraction limit value" is present in Hungary and France (as the maximum volume of fluid to be extracted by a given operation, an indicator to avoid overexploitation);
- Data are public in Hungary (well-log books), and are mostly confidential in Belgium, France, Iceland, and Italy; data are centralised and restricted access is available to operators in Paris Basin, France;
- Reporting frequency is very variable.

Case studies and good practises

The BRGM, in association with ADEME and in consultation with professionals from the geothermal industry, edited very comprehensive **guidelines** for the different phases of geothermal drilling operations in France (Paris Basin). This document represents a good basis to be shared among countries; it is available on-line in its original, French version[6] and English version[7].

The document presents technical aspects associated with well drilling (e.g., well completion, inspection) and provides recommendations for each of them. Several relevant information extracted from the document is listed below:

Well completion *(data sheet 21)*

- Overview of main parameters used for the well completion design and recommendations to ensure the well integrity.
- A technical protective casing is installed in the first hundreds of meters (300-400 m).
- Deeper protected aquifers are secured by means of double casing.

Cement logging *(data sheet 72)*

- *Overview* of available tools for cement logging, their limits, and conditions for a proper cement logging interpretation.

[6] http://infoterre.brgm.fr/rapports/RP-65443-FR.pdf
[7] https://www.geothermies.fr/outils/guides/good-practice-guide-lessons-learned-deep-geothermal-drilling

Casing logging *(data sheet 73)*

- Information about available logging tools for steel and composite casing control.
- A method is proposed to quantify the damage from casing logging measurements.
- Regular casing inspection due to mechanical damage, corrosion, or bacteria is recommended.
- Recommended frequency of inspection:
  - every 3 years for injection wells;
  - every 5 to 6 years for production wells.

Another critical topic is the **abstraction limit**. In France, the limitation of geothermal power extracted inside a defined perimeter is specified within the exploitation license issued for each operator. The regional deconcentrated authority collects notably production history to control the volumes of fluid and thus the geothermal power extracted each year.

In Hungary, where the definition of abstraction limit value ("Mi") is enforced by regulation to prevent the aquifers' depletion (especially when fluids are not reinjected, see also "Discharge of geothermal fluids"), a good practice for its determination exists for Lake Héviz, Europe's largest thermal karstwater lake in the western part of Hungary. There is extensive use of thermal water around the lake (different hospitals, hotels, balneological centres), which required a science-based recommendation for issuing new licenses (i.e., new water abstraction volumes) that do not threaten the yield and temperature of the lake itself and the existing uses.

The developed hydrogeological model made it possible to quantify the available amount of groundwater (water budget) and heat, outlining 3 different protection zones with different Mi values.

Recommendations

1. **Sharing and adopting** best practice regarding well design, monitoring, and abstraction limit

Guidelines to evaluate and control wells would be an improvement to the current practices that rely on the operators' expertise. For example, the mentioned guidelines used in France[7] (based on the experience acquired in the Paris Basin) can be taken into consideration as a basis for

the harmonized best practices, notably protection of shallow aquifers. It would also be important to establish guidelines to handle the most difficult cases, such as if corrosive fluids or gas co-production are present.

2. Making evidence of water monitoring and control available to the public

Data from groundwater monitoring, to follow potential impacts on other aquifers above the target formation, should be available to experts, e.g., national observatories, geological surveys (raw data), and the general public (in aggregated form, presenting the main conclusions regarding the control and monitoring carried out to avoid incorrect use). This recommendation implies adopting an Open Data Policy; it links to the topic “Data sharing”.

3. Enforcing control of aquifers

The current legislation (Water Act[Error! Bookmark not defined.Error! Bookmark not defined.]) regulates the control of the quality and quantity of aquifers. Regulations are applied in most cases, but if this control is not carried out or information is scarce, the changes in aquifers' status may be perceived as linked to geothermal operations. In such cases, information on geothermal well integrity solves the issue; however, the monitoring of aquifers’ quality (e.g., chemical and temperature control) and quantity (e.g., groundwater levels) and data sharing should be an established good practice to be organised at the local level. See “Creation of local benefit” for a reference to this recommendation.

4. Evaluate the medium and long-term behaviour of the geothermal reservoir status

First, the medium and long-term behaviour of the geothermal reservoir should be assessed by numerical modelling based on existing data and on the foreseen production scenario. Then, the models must be calibrated and updated once historical data becomes available. This evaluation and the reservoir follow-up and control would testify to the sustainable use of geothermal reservoirs, i.e., that abstraction does not exceed the recharge rates (natural, or *via* reinjection of used geothermal fluids) or alter the chemical composition. Data should be periodically provided to the controlling authorities.

Aeriform emissions

This aspect covers the legal framework established to mitigate potential geothermal fluid aeriform emissions during well drilling and geothermal plant operations. The European and national environmental and mining laws cover most issues, including reporting of accidental emissions. Besides decrees implementing European directives related to air emission and air quality, the potential impacts of the aeriform emission of geothermal fluids are regulated mainly through best practices of operators and national/regional guidelines.

It is necessary to distinguish between the two main phases of a geothermal project when emission may occur.

Regarding the **potential aeriform emissions to the atmosphere during drilling and testing of geothermal well,** the situation among the countries mapped in our studies is synthetised in Fig. 3 (see the Annex for more details).

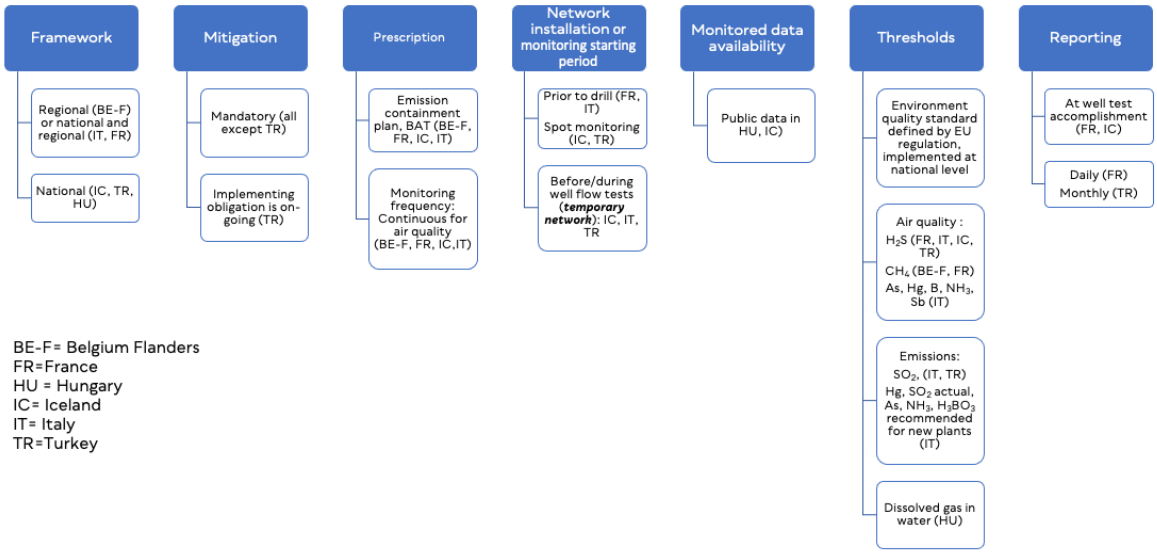

Figure 3 Diagram showing in synthesis how regulations and solutions for public health and safety issues are established at the national level in the GEOENVI participating countries to mitigate the potential impacts and risks of aeriform emission of geothermal fluids ***during the well drilling phase, including flow test****.*

The analysis of the collected data showed several similarities:

- Standard procedures of expert operators already foresee monitoring systems at rig sites, a Blow Out Preventer (BOP) to stop the operation and a temporary monitoring

system during flow tests to mitigate accidental spills and exceedance of thresholds fixed by law;

- EU regulation, implemented at the national level, defines environmental quality standards;
- Belgium-Flanders, France, Iceland, and Italy require air quality monitoring;

Air quality thresholds (beyond those set by EU) are set in Belgium-Flanders, France, Iceland, Italy, and Turkey. Emissions are controlled in Belgium-Flanders, France, Italy, and Turkey. Usually, the gas monitoring is mandatory during drilling in the bounds of the drilling yard, whereas outside the drilling yard the gas monitoring is due during flow tests on the base of the EIA requirements.

There are, however, also many differences:

- For standards not set at the EU level, and although, for example, the World Health Organisation[8] establishes air quality guidelines, variable thresholds are adopted at the national level. E.g., air quality thresholds for H_2S are different in France, Italy, Iceland, and Turkey, as are those for CH_4 in Belgium-Flanders, France and Hungary;
- Monitoring data are public only in Hungary and Iceland. Italy and Belgium-Flanders release partial data;
- The frequency of reporting to authority is variable.

Regarding the **potential aeriform emissions to the atmosphere during the geothermal plant operation and maintenance**, the situation among the countries mapped in our studies is synthetised in Figs. 4.

[8] http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/pre2009/who-air-quality-guidelines-for-europe,-2nd-edition,-2000-cd-rom-version

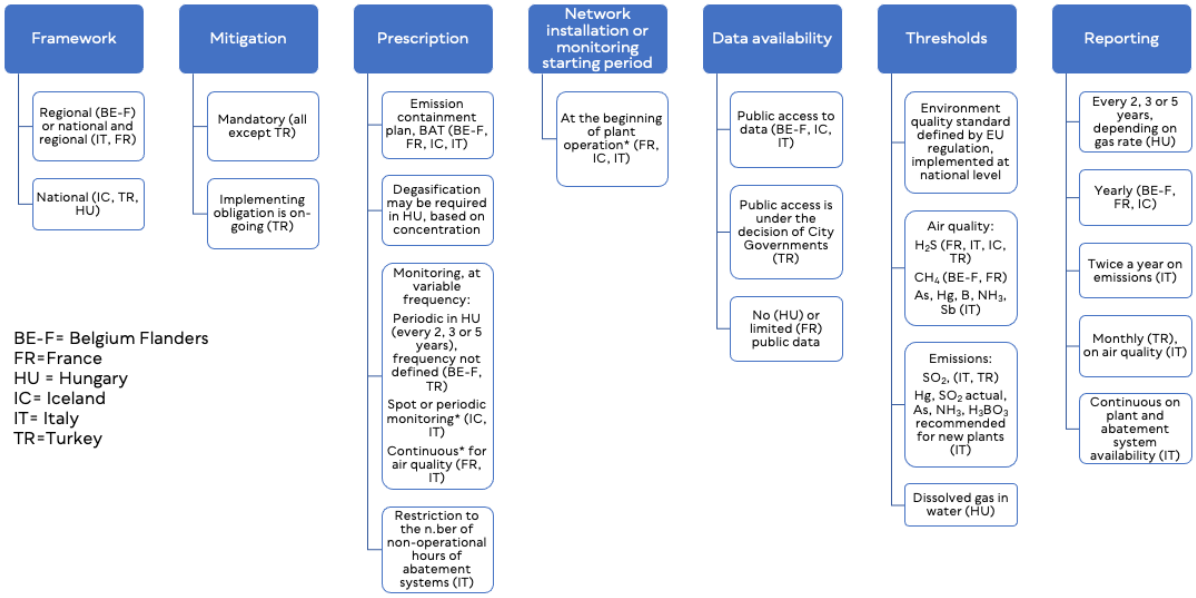

Figure 4 Diagram showing in synthesis how regulations and solutions for health and safety issues are established at the national level in the GEOENVI participating countries to mitigate the potential impacts of aeriform emission of geothermal fluids ***during the plant operations****.*

The analysis of the collected data showed several similarities:

- Environment quality standard defined by the EU regulation are implemented at the national level;
- Emission containment plan and the Best Available Technologies (BAT) are required in most countries (Belgium-Flanders, France, Iceland, Italy);
- Permanent networks for air quality are adopted in all countries.

There are, however, also many differences:

- Monitoring frequency is very variable;
- The frequency of reporting to authority is very variable;
- For standards not set at the EU level, and although, for example, the World Health Organisation[9] establishes air quality guidelines, variable thresholds are adopted at the national level. E.g., air quality thresholds for H_2S are different in France, Italy, Iceland, and Turkey, as are those for CH_4 in Belgium-Flanders, France and Hungary;
- A restriction to the number of non-operational hours of abatement systems is required only in Italy;

[9] http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/pre2009/who-air-quality-guidelines-for-europe,-2nd-edition,-2000-cd-rom-version

- Degasification is required in Hungary (diversified for various levels of gas content);
- Data are public only in Iceland and Italy.

Case studies and good practises

In **Hungary** emissions are strictly regulated, as geothermal fluids in the Pannonian Basin are often very rich in gas (methane). Gas analyses are required:

- during drilling;
- during workover/ cleaning of the well;
- during operation at the frequency defined in the operational license (individual).

Produced thermal waters are classified into 3 categories according to their measured gas content at 1013 millibar pressure and 20 °C temperature:

- "A" below the threshold of 0,8 l/m^3;
- "B" between 0,8-10 l/m^3;
- "C" above 10 l/m^3.

The Decree describes in detail the procedure of analyses, which can be done only by nationally accredited laboratories. The analyses are a pre-requisite to get an operational license for water wells. Degasification is compulsory in water falling into category "C", applying an MSZ-10-226 certificated degasifying unit. In category "B", the degasification has to be done under the normal operational circumstances, while in category "A" it is not required. The degasification has to be done in a way that does not cause the deterioration of water quality.

The gas content has to be regularly monitored with repeated analyses: in category "A" – every 5 years, in category "B" – every 3 years, in category "C" – every 2 years.

In **Tuscany, Italy**, the legislation on air quality and emissions provides guidelines and air quality and emission limits from plants. Regional legislation in Tuscany enforces further limits to geothermal power plants, imposing air concentration thresholds and defining emission limits, procedures for sampling and analysis of geothermal emissions, max number of non-operational hours for plant, and adoption of abatement systems (Tables 1, 2, and 3). Besides reducing emissions below the limits defined by regulation, abatement systems reduce ammonia emissions by up to 80-90%.

In geothermal areas, air quality is monitored by the operator (Enel Green Power) through a system of 18 monitoring stations that constantly measure the concentration of H_2S in ambient air. The Regional Environmental Protection Agency (ARPAT) validates the measured values. Moreover, ARPAT runs: 1) a fixed station near Larderello, which monitors H_2S, O_3, NO_2, and

PM10. The station belongs to the Regional Network of air quality stations and is also part of the Copernicus Atmosphere Monitoring Service (CAMS[10]); 2) two mobile laboratories which are also able to measure mercury concentration in air. All data are published through the ARPAT and the Enel Green Power websites.

Table 1: Air quality limits of reference in Tuscany, Italy, as reported in the regional guidelines

Parameter	Concentration	Reference
Hydrogen Sulphide (H_2S)	150 µg/m^3 daily average maximum air concentration	(1)
	100 µg/m^3 for 1-14 days (maximum average over the period)	(2)
	20 µg/m^3 up to 90 days (maximum average over the period)	(2)
Arsenic (As)	6 ng/m^3 yearly average	Target value from EC directive 2004/107/CE of 18/12/2004 and D. Lgs. 152/2007
Mercury (Hg)	0.2 µg/m^3	(3) December 2007. Reference year 2001
Boron (B)	20 µg/m^3 daily average	Confidence interval 100 with respect to TLV-TWA of 2 mg/m^3 reported in (4) (inorganic boron)
	10 µg/m^3 > for 1-14 days (average over the period)	(3) December 2007
Ammonia (NH_3)	170 µg/m^3 daily average	Confidence interval 100 with respect to TLV-TWA of 17 mg/m^3 reported in (4) (ammonia)
	70 µg/m^3> for 1-14 days (average over the period)	(3) Reference year 2004
Antimonium (Sb)	5 µg/m^3 daily average	Confidence interval 100 with respect to TLV-TWA of 0.5 mg/m^3 reported in (4) (antimonium)

TLV-TWA = Time Weighted Average.
Ref: (1) WHO, 2000; (2) WHO – IPCS; (3) MRL Minimal Risk Level (ATSDR); (4) ACGIH, 2006.

[10] https://atmosphere.copernicus.eu

Table 2: Emission limits allowed in Tuscany (Italy) plants

Equipment	H_2S kg/h	Hg g/h	SO_2 g/h
Outlet of the AMIS abatement plant	3	2	150
Natural drift cooling towers for plants ≤ 20 MW	10*	4	
Natural drift cooling towers for plants > 20 MW	20*	8	
Forced drift cooling towers for plants ≤ 20 MW	30*	10	
Forced drift cooling towers for plants between 20 and 60 MW	60*	15	
Forced drift cooling towers for plants > 60 MW	100*	20	

* Overall emission limit from the cooling tower (AMIS included)

Table 3: Maximum plant stop hours per year allowed in Tuscany (Italy) plants

Type of stop	Limit
Hours of overall non-operational plant	2% in 8760 hours / year
Hours of operation of AMIS plants / overall operational time of the facility	≥ 98%

Recommendations regarding the geothermal well drilling phase

1. **Defining air quality baseline**

Air quality should be monitored at the plant site and additional locations in the surrounding area prior to the start of any geothermal operation, to establish a baseline.

2. Enforcing air quality monitoring during well drilling

At least when drilling potentially gas-bearing formations, air quality monitoring should be enforced in the bounds of the drilling yard.

3. Enforcing air-quality monitoring during well flow tests

Outside the drilling yard, gas monitoring should be enforced during flow tests.

4. Always equipping the drilling rig with tools (e.g. Blow Out Preventer) to prevent accidental gas flow at geothermal wells

5. Enforce mitigation plan to prevent accidental emissions during drilling

It should include: trained personnel (to be certified, e.g., IWCF), perform safety exercises during drilling activity, well design and implementation to face the risk. Maximum flow test overall duration or total emitted volume, to be defined case by case depending on the gas rate, should also be included.

6. Data reporting to the authority

For each drilled well, data should be provided to controlling authorities. They should include also flow test durations or total emitted volume, to be checked against what was declared in the mitigation plan. Controlling authorities should be informed of the flow test schedule to allow them to verify the operations.

Recommendations regarding the geothermal plant operation phase

1. Establishing air quality standards for pollutants currently not covered by EU regulations (H_2S, Hg, …)

Guidelines of the World Health Organization are currently a reference, but air quality standards would harmonise the situation and be applied not only to the geothermal sector.

2. **Enforcing c**ontinuous or frequent air quality check

During plant operation, the air quality check should be performed at sites surrounding the plant, and their location defined in the emission containment plan. Frequency should be decided case by case, depending on the level of risk assessed by using state-of-the-art air quality models.

3. Monitoring and abatement plan to contain emissions

In case of predictable significant emissions**,** the following list of actions and practices is recommended.

- Total reinjection or adoption of abatement system to reduce emissions

Mitigation by total reinjection or adoption of adequate abatement systems for H_2S and other aeriform pollutants should also include the maximum amount of non-reinjected gas for reinjection and the definition of the maximum number of non-operational hours for abatement systems.

- Continuous monitoring

This may also include self-monitoring of operators checked by controlling authorities

Main recommendation of Promoting Research and Innovation on strategic topics

- Further research for **zero emission plants and total reinjection**, to increase the environmental performance of some geothermal applications.
- Further understanding of **natural emissions allowing to evaluate the real contribution of the emissions at the power plant** during operation and the effect on natural emissions in the area hosting the geothermal plants. This research would set the appropriate concepts for defining the values to be considered in LCA studies and other environmental assessments and would contribute to the current debate on the matter in Europe (ETS, emission limits). This is a crucial issue to be addressed.
- The definition of Best Available Technologies (BAT) for abatement systems at European level (e.g., a BREF document from the Seville JRC, which defines BAT to be applied to enforce the IPPC regulations[11]).
- Further understanding of **health effects of long-term exposure** to a low concentration of hydrogen sulphide emissions. This aspect, which is of higher impact in other sectors, has created some concern also in the geothermal sector, even though monitored concentrations are well below the limits given by the World Health Organisation and short-term effects of these emissions on human health are excluded in the European context. A clear understanding of the effects of long-term exposure to a low concentration of this substance is missing at the scientific level. As evidenced in a recent review carried out in the frame of the GEOENVI project (Bustaffa et al., 2020), this matter is particularly complex, due to the heterogeneous and sometimes conflicting results and the difficulty to distinguish the exposure among a variety of confounding factors. A large and coordinated effort and a harmonised design of studies is necessary on these aspects.

[11] https://eippcb.jrc.ec.europa.eu/reference

References

ACGIH (American Conference of Governmental Industrial Hygienists), 2006. Guide to Occupational Exposure Values, 168 pp. https://www.acgih.org/forms/store/ProductFormPublic/guide-to-occupational-exposure-values-2006

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WHO – IPCS, WHO International Programme on Chemical Safety. Open Report Documents (continuously updated) http://www.who.int/ipcs/methods/harmonization/en/

Discharge of geothermal fluids

This aspect covers the legal framework to mitigate **potential** chemical and temperature effects due to both the discharge of geothermal water and drilling fluids onto and into surface/underground water bodies and the reinjection of geothermal fluids after production.

Regulation on waste (e.g., of drilling mud) is comprehensive, and no further action is required.

Most of the issues related to water-ecosystem protection are covered by the Water Act[5] and its national implementations, including minimization of water amount.

The situation among the countries mapped in our studies (see the Annex, Discharge of geothermal fluids template) is resumed in Fig. 5.

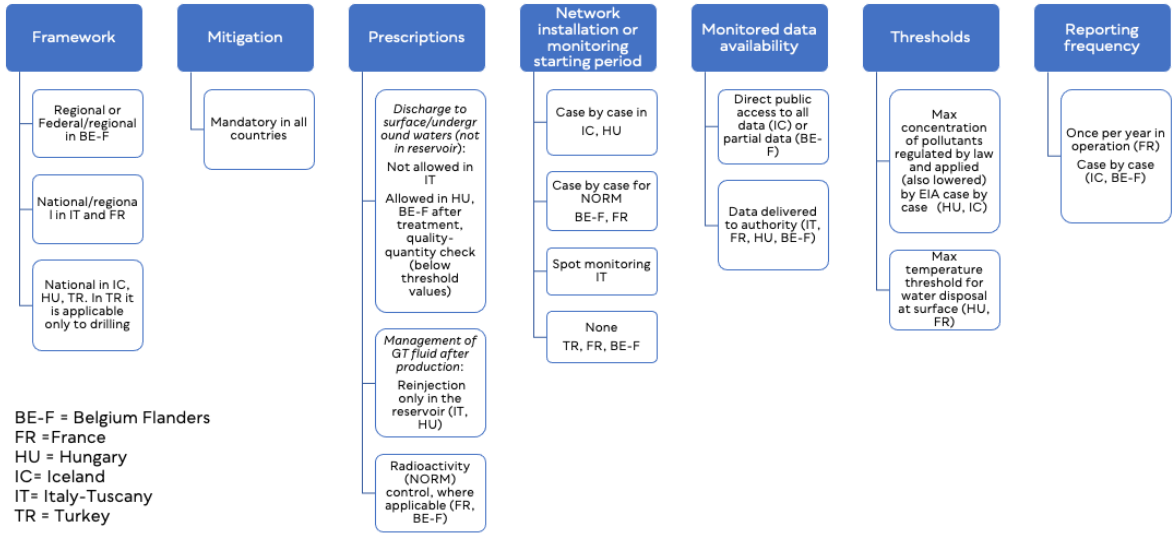

Figure 5 Diagram resuming how regulations and solutions for safety issues are established at the national level in the GEOENVI participating countries to mitigate the potential impacts of the discharge of geothermal fluids.

The analysis of the collected data showed several similarities:

- Controlled water management, both as management of waste and water and ecosystem protection, is required in all countries;
- Where applied, reinjection is allowed only in the same reservoir;
- Only geothermal fluids are used for the injection in the reservoir.

There are, however, also many differences:

- Discharge of water in surface water bodies, after quality-quantity check, is allowed in some countries and forbidden in others;
- Only Hungary establishes differential thresholds for pollutants depending on the application (e.g., balneology, district heating, etc.);
- Monitoring data are public only in Iceland. Partial release of data is mentioned in Italy and Belgium-Flanders.

Case studies and good practice

A good example of safety practice is available in **Hungary**, where the thermal groundwater abstracted for energetic purposes may be reinjected to the same aquifer after utilization. Still, surface disposal/discharge is also allowed. The input of used water into water bodies can happen only in a way that does not threaten the natural processes and the quality and quantity renewal of the water reserves.

The national regulation contains provisions on the threshold values of various contaminating materials. It specifies threshold values for thermal water discharge into surface recipients (e.g., rivers, streams) ranked in 3 categories: therapeutic, balneological, and energetic. The highest allowable threshold values are provided for the therapeutic utilization (5000 mg/l of total dissolved solids), thus appreciating its economic and public health value. In contrast, lower values are allowed for balneological (2000 mg/l) and energetic (3000 mg/l) utilization. The allowed heat load is 30 °C in all 3 categories (i.e., this is the maximum allowed temperature at which thermal water can be released at the surface).

If any of the used thermal water components are above the threshold values, then the thermal water has to be discharged into an artificial lake. In case the used thermal water and the cleaned water of the settlement have no harmful interactions, they may be drained together.

Recommendations

1. Where surface discharge is allowed, establishing frequent monitoring and harmonisation of temperature and chemical thresholds for geothermal water

As in Hungary, where surface discharge is allowed, a comprehensive monitoring system would allow an appropriate environmental assessment and control. Some environmental quality parameters may be controlled remotely.

2. Executing reinjection of geothermal fluids

This recommendation, aimed at minimising the reservoirs' depletion and avoiding chemical and thermal impacts on surface ecosystems, should be applied to direct use of geothermal fluids, or at least those involving flow rates higher than 10 litres/sec. In the case of bathing and swimming applications, where human contaminations are unavoidable, the thermal water not getting in direct contact with humans (e.g., used only for heating of the pools) should also be reinjected.

3. Harmonisation of chemical classification for the toxicity of inhibitors in Europe and among sectors (e.g., oil and gas)

Recommendations for process topics

For each topic, information has been collected and organized utilizing templates that have been filled for the interested countries. They are available in Annex 1.

Complex licensing and delays

Harvesting geothermal energy requires licensing. There are different approaches for licensing applied in the selected countries (see the Annex for collected data). In general, licenses are provided in two phases as exploration and exploitation by related state authorities.

Exploration license presents approval for feasibility studies to understand the existence and dimensions of the geothermal resource. The duration of this license is (i) 5 to 7 years in Belgium (5 for Flanders, 7 for Wallonia); (ii) 3 to 5 years in France; (iii) 4+2 years in Italy; and, (iv) 3+1 years in Turkey. Hungary provides a water license up to 2,500 meters and a concession for resources deeper than 2,500 meters.

Licensing methodology in Iceland is quite unique compared to other countries. Research, prospection, and utilisation of the resource is defined under Resource Act, and power generation is the topic of the Electricity Act. The duration of provided licenses varies up to 65 years.

Exploitation license presents approval to harvest the discovered resources. There is no specific exploitation license provided in Iceland. Belgium and France offer an open duration, which is monitored in line with compliance of activities from the environmental point of view. This duration is 30 years in Italy and 30 + 10 years in Turkey.

With the exception of Iceland, where licensing is under the responsibility of a single actor, there are too many actors involved in licensing processes. These actors create complexity and slow down the work process by increased bureaucracy.

All countries require an environmental permit to grant any type of license.

Granted licenses define the frame on how to explore and/or exploit a geothermal resource. In Hungary there is a specific permit for heating plants.

In Turkey, since the geothermal law is power generation dominated, there are no specific conditions for direct use applications (heating and cooling for instance). There is a Heat Law under discussion within the Ministry of Energy that might fill such a gap and provide responsive legislation.

A challenge to overcome in selected countries is the required time to have a license granted. Especially EIA approval takes the most of the authorization time in all countries. Specifically, in France receiving a drilling permit can take up to 18 months.

The term 'license trade' sets another challenge for developers. Apart from Italy, there is no criterion on financial capabilities requested by authorities. For instance, in Turkey any legal entity or individual person can apply for an exploration license without questioning the capabilities of performing exploration activities.

Below a list of challenges is presented within the investigated countries:

- The investigated countries, except Iceland, are facing challenges due to the lack of centralized management. Such challenges are mainly caused by missing responsive communication between different permitting process actors that slow down the procedures.
- In some cases, EIA process may take too long (France, Iceland, Italy).
- Various issues should be solved in Turkey: the "license trade" during the early years of power generation development created a handover. Furthermore, its legislation is conceived for power generation only, and a frame for direct use applications is missing. Moreover, Turkey faces acceptance challenges for power generation due to some improper management of a few plants in the past.

Recommendations

1. Organizing the permitting process as a "one-stop-shop"

Following the example of Iceland, where Orkustofnun represents the single actor- central manager of the processes, this recommendation refers to how a unique permitting process, including licensing the exploration, utilization, and power plant operation phases, helps to avoid complexity and delays.

2. Setting up a Best Practices Guide

Of use for the national and local authorities and administrations, the project developers, and financial institutions, such a guide is meant to improve knowledge and information exchange among all the actors involved.

3. Ensuring **competent authorities possess the necessary knowledge, skills and training**

The importance of adequate competences to assess the license and permit applications is underlined, to allow for sound guidance and evaluation and an efficient process.

4. **Controlling the technical and financial capability** of license applicants

Licensing of geothermal resources exploitation brought the creation of a “license trade”. When individuals or organizations acquire licenses, they should prove their commitment to respect law enforcement. To ensure the full execution of the projects, a certification of financial capacity and the payment of a guarantee or deposit should be requested.

Environmental Impact Assessment

Environmental Impact Assessment (EIA), as defined under Directive 2011/92/EU (then amended by Directive 2014/52/EU), is a key element of the EU legislation dealing with the environmental impacts of projects. EIA is implemented in each GEOENVI country, although the way it is incorporated in the overall permitting procedure differs (deliverable 4.1). A particular challenge emerging from the GEOENVI workshop discussion is matching a generic regulatory framework and EIA procedures with the specific nature of individual deep geothermal projects and the specific types of environmental impacts and risks that may apply. The analysis therefore focussed on the questions: are ‘sectorial’, i.e., deep geothermal EIA guidelines necessary? How to design them so that they are clear and transparent in terms of requirements and expectations, yet efficient and flexible in accounting for differences among deep geothermal projects and avoiding unnecessary burdens for applicants? Information was collected from different GEOENVI countries on how the EIA procedures for deep geothermal energy are implemented and to what extent specific guidelines, predefined thresholds, and mitigation measures for the geothermal sector are defined (see the Annex for details).

A main message is that EIA guidance remains rather general. The EIA procedure is quite similar across the studied countries, following the EU legislation regarding the elements the

EIA must include[12] (Table 4). In some cases, national guidelines are available to the operator (Belgium, France, Italy), but they are generally not tailored to deep geothermal specificities (only France includes elements concerning geothermal drilling). The scope of the EIA is defined in the general regulation on the EIA, and a standard list of impacts must be followed by the developer. However, the developer can assess the importance of the impacts in the report due according to art. 4 and 5 of the Directive, and then analyse in deeper detail the most important ones. All the countries have thresholds defined by general regulations and laws. In most countries, no mitigation measures are imposed by law before the EIA procedures (France, Italy, Hungary), although they must be described in the EIA (Belgium, Italy, France). The EU directive provides the possibility to be exempted from a full EIA (only for exploration and drilling projects) based on an Environmental Preliminary Study (EPS) or 'EIA screening', and similar procedures also apply to non-EU countries. However, a variety of exemptions criteria may be granted, such as the list of activities subject to an EIA, the type of permits concerned, and the depth of drilling. Even if some exemption of EIA can be granted (Belgium, France, Italy), in practice a full EIA is carried out by the developers. One reason is that requesting an exemption leads to a similar effort compared to going through the entire EIA process.

Viewpoints on how EIA procedures could be improved were collected from the GEOENVI consortium and further discussed with the stakeholders of the national and trans-national fora. Besides the need for dedicated guidelines, this revealed the need for more flexibility in the EIA procedure, accounting for the possibility to update EIAs as new information becomes available, and to take into account the individual nature of deep geothermal projects, avoiding to pose unnecessary burden for applicants to report on environmental impacts of lesser relevance. The need for appropriate skills at the side of authorities was highlighted, too.

[12] See the general EU guidance on EIA here: https://ec.europa.eu/environment/eia/eia-support.htm

Table 4: Guidance on EIA in different countries

Country	EIA guideline	Specifics for DGE	Scope: Environmental impacts to consider	Thresholds	Mitigation measures
Belgium	Yes	No, it is a generic guideline	The list of impact is defined by the developer. Generic guidelines included in the EIA office portal for some EIs.	Included in the regulation. The guidelines per discipline include thresholds (regulated), generic for all sectors	There is a handbook with general mitigation measures
France	Yes	Yes, for geothermal drilling	Standard list of impacts included in the general EIA require examination for DG	No, but defined in the regulation	The EIA guideline doesn't provide prescription for the mitigation of EI.
Hungary	No	No, not specifics for DG	No, but defined in the regulation	No, but defined in the regulation	N/A
Italy	No, only recommendations to avoid EI&R	No, not specifics for DG	Standard list of impacts included in the general EIA; the developer declares what does not apply	In Tuscany included in the EIA regulation.	Not in EIA regulation, prescriptions are given in the EIA decision.

Recommendations

1. Drafting simple EIA guidelines dedicated to deep geothermal

Dedicated and simple EIA guidelines for deep geothermal development, listing the specific environmental effects to be evaluated, would provide added value on at least three main aspects. First, it is important that the developers and authorities together tailor the scope of the EIA to the specific characteristics of the project and of the geological context, and the guideline should give directions on how this flexibility can be implemented.

Second, dedicated guidelines would provide clarity on the EIA process. The guidelines could take the form of a Table of Contents and clarify what documents and information are required for each part. This would facilitate the EIA procedures, as would reduce the requests for integration and the duplication of data in different documents.
Third, it would provide clarity and harmonization of the procedures for EIA exemption so that the overall burden of EIA – if the nature of the project allows it – can be reduced.
It is suggested to include also an estimation of environmental benefits, like avoided GHG emissions and the contribution to renewable energy targets of the member states.

2. More flexibility in the process from exploration to implementation

The process could be more flexible by introducing the possibility to update previous full EIAs to a new situation. Two cases are considered: 1) the modification of an already existing environmental permit for which already a full EIA was submitted, 2) an update for the EIA as more information becomes available, for example, after the exploration phase. The latter would account for uncertainty, as impacts and risk are not entirely known at the start of the exploration. A point of attention, however, is to avoid that too rigid consecutive update requirements become a source of delays. A full EIA (covering both drilling and plant operation), to be updated after the drilling results are available, would help in this view.

3. Ensure appropriate competences and skills at the side of authorities

Finally, the importance of adequate competences on the side of the authorities is underlined to allow for good guidance and evaluation and an efficient process.

4. Define Best Available Technologies for deep geothermal

As for other industrial sectors, a list of Best Available Technologies would be an important reference for the EIA.

Case studies and good practice

In developing dedicated guidance for the deep geothermal EIA, the following current good practices provide a starting point:

- The generic EIA guidance documents[12].

- The Italian guidelines on mitigation measures for deep geothermal energy (only available in Italian)[13] (considered by Italian stakeholders a starting point for more detailed guidelines).
- Regional (Tuscany, Italy) decree establishing "Guidelines for limiting atmospheric emissions from geothermal power plants", which indicates the prescriptions to be used for the EIA and is the reference for aeriform emissions and related BAT.
- The Good Practice Guide for lessons learned from Deep Geothermal Drilling, prepared in France[6].
- The Handbook for the Best Practices for Geothermal Drilling[14], prepared in the U.S.A. in 2010.

Information sharing

The availability of reliable information on geothermal utilisation can be crucial when it comes to the public acceptance of geothermal projects as well as for comparison to other renewable energy projects. Official statistics and industry statistics on geothermal are often inoperable and fragmented[15]. In many countries, statistics on geothermal are not collected systematically, often because the utilisation is considered too small to devote resources to the collection, and so estimates or other, often inaccurate, methods are used. This can prove to be problematic for the geothermal industry when there are no reliable statistics to use for research or the promotion of geothermal energy as a reliable energy source. In addition, the statistics and information collected are not easily available or even very difficult to access, and the lack of data can be interpreted as a lack of transparency.

In light of this, the GEOENVI partners decided to review the status of information sharing across some of the partner countries. A template was set up for all the countries of relevance to complete (see the Annex for details).

The analysis of the collected data showed several similarities:

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[13] https://unmig.mise.gov.it/images/docs/linee-guida-geotermia.pdf
[14] https://www1.eere.energy.gov/geothermal/pdfs/drillinghandbook.pdf
[15] https://orkustofnun.is/gogn/Skyrslur/OS-2015/ERA-NET-International-Collection-of-Geothermal-Energy-Statistics.pdf

- Exploitation data are generally confidential in Italy and France until the end of license/concession. In Iceland, the data are confidential unless stated otherwise in the license; in practice, the licenses have stated that the data are public unless the license holder requests confidentiality;
- All countries have a national framework, and all are mandatory;
- Exploration data are generally available, usually in the form of reports;
- Iceland and Italy publish available exploitation data (at the end of concessions if applicable);
- Flanders (Belgium), Hungary, Iceland, and Italy publish data online trough interactive websites and map portals;
- Generally, the public is not aware of the available public data in France, Iceland, Hungary, and Italy;
- Data are considered trustworthy in Iceland, Italy and Hungary.

There are, however, also many differences:

- Iceland has an independent appellate committee on information matters, which Hungary, France, and Italy do not have;
- There are different data sharing practices on public data availability;
- The typology of data collection between countries is variable;
- In France and Belgium Flanders, the information is only available upon request;
- The amount of data available among the countries is variable. Iceland, Hungary, and Italy report data in tables and PDFs. They are not, at this stage, machine-readable.

Case studies and good practice

Identification of available good practices from the countries was mainly from Hungary, Iceland, and Italy. **Iceland** publishes exploitation data annually, which is mostly used by experts; it includes volume produced, volume consumed, energy extracted in TJ, the temperature of the used fluid, and more. Currently, the data is published in tables and PDFs, but a more interactive portal is under development to improve data accessibility for the public. All publicly funded reports and data are available online. The available data are considered trustworthy and understandable.

For **Hungary and Italy**, the available data are also considered trustworthy and understandable, and web tools are used to make the public more aware and ease access to the available data. In Hungary, a fundamental step was taken in sharing information with the

up-to-date and reliable geological, hydrogeological and geophysical data and information about Hungary´s geothermal energy resources *via* a publicly accessible web-site, also in full English version[16]. In Italy, most public data refer to air quality and emission data.

Recommendations

1. Define a European standard on information sharing

Transparency (pros and cons) should be promoted, allowing comparisons. The standard should contain a minimum amount of information, but countries are encouraged to go even further in sharing information with the public.

The adoption of project management tools like the GSAP that has proven its use in Iceland on geothermal projects (see Theistareykir[17] and Hellisheidi[18] power plants) may improve data consistency.

2. Selecting relevant information

The public should not be overloaded with information, and a balance should be found between confidential and non-confidential data. The collection should start before the development and include mitigation measures and positive impacts. Systematic data collection may help to improve the quality of data that is being published. To be able to compare geothermal utilisation to the utilisation of other energy media, comparable data should be collected. They include: the extracted energy in TJ (requires data about flowrate and temperature); the produced energy per category; a distinction between primary activity producers and auto-producers, and a reasonable estimation where data are not collected.

The systematic collection also implies adopting FAIR (Findable, Accessible, Interoperable and Reusable) principles in data management. Particular attention should be given to providing detailed metadata and storing data in repositories that guarantee long-term preservation to data.

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[16] https://map.mbfsz.gov.hu/ogre_en

[17] https://www.landsvirkjun.com/company/mediacentre/news/news-read/theistareykir-first-geothermal-power-plant-to-undergo-gsap-sustainability-assessment

[18] https://www.dv.is/wp-content/uploads/2018/06/Hellisheidi-Assessment-Report_final-June-5-2018.pdf

3. Adapting the communication to the target audience

Mediation work is needed, and clear terminology should be adopted. Also, the best dissemination support should be chosen according to the target group.

4. Improving data sharing and accessibility of information

In some countries, data are only available upon request; therefore, it is recommended that data should be made FAIR and open (i.e., published online) for easier access by the public. According to Iceland's experience, the data that seems most beneficial to the public are energy extracted in TJ, flowrate, volume used per usage category (see categories used by Eurostat, IEA, and other organizations that collect statistics), and tariffs. When requests for information are denied, the possibility to appeal to an independent committee, such as in Iceland, is recommended. An experience, as in Iceland, shows that the sharing of reliable information and data is very important in order to gain public acceptance.

Local Benefits

Geothermal development implies a series of positive impacts since energy production from a local, renewable, and low carbon source contributes to climate neutrality and the efficiency of processes, reduces energy dependence, and boost competitiveness, resilience, and utility for citizens and society.

An aspect of the relationship between the technological harnessing of geothermal resources and the societies and local communities in which these developments occur is the creation of local benefits and valorisation of those directly connected to the development. Moreover, grassroots energy innovation should be involved in any energy development. Guidelines and regulations may provide important pillars for embedding the local benefit aspects in the geothermal energy governance.

Various actions towards these objectives are visible at the local level. Some main examples collected among partner countries (France, Iceland, Italy) have shown that there are many different ways to enhance the local sharing of deep geothermal benefits (see the Annex for details). For example, all three countries provide financial support to geothermal district heating projects; however, nature (national vs. regional funding, administrative funds or derived from royalties) and organization of the financial support (loan, total or partial funding) is somewhat

different. It should also be noted that local benefits such as territorial attractiveness and tourism, an increase of available jobs, and royalties-derived funding for local municipalities are available in any geothermal project. However, there is not clear information on these aspects in most European countries, and in general at the global level.

Following the studied examples and the debate among partners and during the national workshops, a list of recommendations has been prepared; a local experience, such as the one of Tuscany in Italy, of using a part of royalties for supporting research and communication activities, and for promoting the uses of RES (renewable energy sources) technologies, including geothermal application, has given further hints for the proposed recommendations.

Recommendations

1. Establishing a Fund derived from taxes/royalties to support the local communities

The Fund should promote a local economic development beyond the usual use of royalties and the direct benefits of geothermal projects that produce royalties, and could also be used to fund or co-fund activities of Recommendations 2 and 3. However, it is encouraged to use the Fund to promote renewable energy technologies' applications and improve environmental control of the area, such as shallow aquifers, local ecosystems and surface waters (this topic links to *Aquifers' interconnection* and *Discharge of geothermal fluids*).

2. Supporting local utilization of geothermal heat

Utilization of geothermal heat for heating and cooling of spaces and processes, in series or as cascade heat in the main geothermal projects, or as independent, small projects, aims to create a circular and co-designed use of local geothermal resources. The involvement of SMEs should be encouraged.

3. Establishing a plan for valorising local benefits

The plan should cover:

- a periodical registration of the contribution of geothermal development to the economy of the nation/region/province;
- communication of geothermal information, including those related to activities funded by Recommendation 1, those related to Recommendation 2, and those of the data registry (the previous point);

- training and educational activities to foster local applications should be also encouraged at local and national level.

The registry should include:

- the number of jobs involved in the geothermal development, both those directly linked to the sector and undirect jobs in projects supported by geothermal development or associated activity (e.g., those established in Recommendations 1 and 2);
- the environmental benefits, such as avoided GHG emissions both for local and national level;
- the economic benefits such as cost reduction (life cycle cost) of heating, avoided imported fuels, geothermal revenues.

Public participation

Before a deep geothermal project is granted a development consent[19], the public must be given the opportunity to be informed and express its opinion. EU legislation on public participation foresees that the member states determine how they wish to inform the public[20]. Based on this overarching legal obligation of public participation, which takes place with the legal inquiry[21], two questions have been asked:

1. How is the legal obligation to inform the public organized among the GEOENVI countries?

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[19] or in other words the decision by which a project can or cannot take place

[20] *"(a) the public is informed, whether by public notices or other appropriate means (…), about any proposals for such plans or programs or for their modification or review and that relevant information about such proposals is made available to the public including inter alia information about the right to participate in decision-making and about the competent authority to which comments or questions may be submitted;*
(b) the public is entitled to express comments and opinions when all options are open before decisions on the plans and programs are made;
(c) in making those decisions, due account shall be taken of the results of the public participation". Art2 Directive 2003/35/EC. Retrieved from: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32003L0035&qid=1599480899608&from=FR

[21] Other formal or informal tools can be used by the operators or authorities to complete this minimum legal requirement

2. What is the reality/quality of the communication between the public and the operators established by those tools?

Flanders (Belgium), France, Hungary, and Italy partially responded to a survey, and the subject was discussed during the 2nd round Italian, Hungarian and French workshops. It is important to note that the source of information was mainly operators and experts (completed with other stakeholders' inputs from the workshops, and some literature for France). The way "geothermal energy managers" understand participation differs from the way the residents understand it (Ruef and al., 2020), so this impacts the recommendations.

Legal obligation to inform the public (public inquiry) in the GEOENVI countries

1. Form of the legal obligation to inform the public: the public inquiry (or through a request for development consent presented with the Environmental Impact Study in Italy)
   - 30 to 90 days;
   - Not always an investigating commissioner (in Iceland, the National planning agency is in charge, in Hungary it is the notary of the respective municipality, in Italy the permitting authority);
   - Information has to be made available (the choice of the medium is free, as well is – at least partially - the content);
   - Formal collection of the comments and questions from the population.

2. Public information/participation in a deep geothermal project-timeline

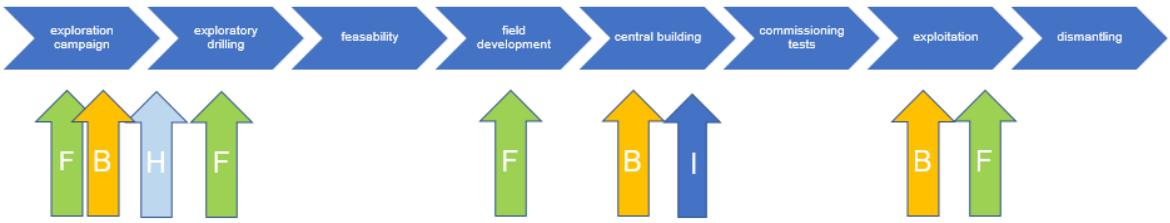

Figure 6 Diagram resuming different timing and occurrence of the public inquiry at the national level in the GEOENVI participating countries. B: Belgium, F: France, H: Hungary, I: Iceland

Quality of the communication between the public and the operators

Scholars in France have demonstrated that the public inquiry does not necessarily reflect the population's position on a project. The public participation may vary a lot from a project to another (Chavot & al., 2016) and could be very low, which questions its representativeness. The opponents can remain silent or choose other ways to express their opposition, like litigation (Baggioni, 2014). “Their function [of the public inquiries] seems to be more to satisfy legal requirements […] than to encourage public participation” (Blatrix 1996, quoted by Chavot & al. 2019). It questions the purpose of public inquiry tool: it may not be to mobilize the maximum of people to express their opinion but to avoid open conflicts and reach a consensus, even if feeble, or just to fulfil the legal requirements (even with a negative opinion of the investigating commissioner, authorities may accept the project).

- Low participation of the population (Hungary, Iceland, France: may vary a lot from a project to another (Chavot & al., 2016));
- Difficulty to communicate “[…] the apparent misunderstanding between citizens who feel poorly informed - even misinformed - and project promoters who think they appropriately communicated” (France, P. Chavot: For example, he observed “[…] when the project’s advocates are claiming that they are limiting the risks, local residents are drawing the conclusion that these risks actually do exist.” “For the promoters, the precautionary principle means that the risks are under control, while for the residents, it should be used to postpone the projects”);
- Difficulty to take into account the opinions expressed, sometimes “unconstructive” (Hungary), on a very engineered object (impression that there is not a lot of practical options to be discussed);

⇒ The public inquiries can reflect a feeble consent or be a “platform for protests” (France (Chavot & al.2019), for the Enhanced Geothermal System (EGS) technology, which is more controversial than the conventional deep geothermal activity developed in the Paris Basin), it is a common democratic issue. Each project has its specificities (unique socio-technical object). The participation process seems to be satisfactory in Flanders on recent projects.

⇒ There are some specificities for geothermal energy:

  ⇒ Often unfamiliar to the public (sub-surface, technical, except for Iceland and “proto-expert” sometimes);

⇒ Development of a geothermal project takes time (difficulty of long-lasting works, Hungary);

⇒ Positive role in the energetic transition should be compared with other options and their advantages, disadvantages, implementation on specific territories.

Recommendations

Recommendations are informed by the above analysis and complemented by the results from the 3rd round GEOENVI workshop on public engagement[22] (see deliverable D4.4).

1. Fostering public engagement policies based on territorial integration

- The territory of a project should be known in depth, understood and respected, including the public and its value, the energy issues and the entire socio-economic and political context as well. This knowledge can only be acquired with the tools provided by social sciences. It will be the key to build a project adapted to the territory, to communicate with and engage the population public in a suitable way. This includes seeking project-based, dynamic communication, information, and participation processes adapted to local characteristics, and combining formal and informal means of communication with the local population.

2. Deepening of the participatory process and stimulating a quality dialogue between the project developers and relevant stakeholders

- Fostering the public participation (e.g., Geothermal project development incorporated in the primary and/or secondary school education programme (Hungary, Flanders), site visits), go further than the legal minimum requirements (with stakeholder committees, pre-project consultation …. Formal and informal tools), with a transparent and harmonized protocol;

[22] https://www.geoenvi.eu/events/targeting-co-ownership-rather-than-acceptability-for-deep-geothermal-projects/

- Improving communication both way (e.g., Wind energy in France: a "package permit" based on "variable features" (number, power, location of wind turbines) was tested offering different scenarios to the population; transparency in Iceland), and mutual knowledge (e.g., need to understand the stakeholder risk perception underlined in Italy);
- Protocols like the Geothermal Sustainability Assessment Protocol GSAP[23], modelled on the Hydropower Sustainability Assessment Protocol and tested in Iceland, can help to take into account the environmental, social, technical, and financial issues in a transparent process;
- Accept the project to be questioned and take the opinions into account (e.g., additional testing for radioactivity in Flanders).
- Expand the perimeter of participation:
  - Geographic perimeter: reach the population actually concerned by the project (neighbourhood cities and intercommunal level[24]);
  - Governance perimeter: importance of the involvement of the local authorities[25], if the general public is difficult to reach, some associations or other stakeholders can be involved.

3. Making communication an ongoing process since the very initial project phase

- An early communication on the project[26] is important, to be proactive;

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[23] https://www.landsvirkjun.is/Media/gsap-theistareykir-assessment-reportfinal-3-may-2017-4.pdf

[24] In France, the fact that only the population of the city where the project takes place is consulted is an issue (P. Chavot). The PI could take into account the population of neighbourhood cities or even the intercommunal level as the project impacts could go further than the administrative boundaries of the city. When working with "facilities classified for environmental protection" (ICPE), the perimeter of the population consultation can be adapted regarding the potential impacts of the facility. This flexibility regarding the perimeter could be relevant for deep geothermal installations.

[25] In France, the consultation of the city councils of the concerned cities (in the AR, PER, concession, authorization for exploitation or authorization to open mining work) has just been introduced in the French system (decree of December 2019) which seems to go in the right direction. In an innovative engagement process for wind energy, the consultation of the local authorities takes place before the public enquiry and the city councils' opinions are attached to the documentation of the public enquiry; It gives more visibility to the local authorities' opinions and will invite them to be consistent and debate openly about the subject. This could be promoted in the geothermal sector too.

[26] In France, for the offshore wind farms, an innovative process has been put in place, as a try, by the public authorities and more especially the National Commission on public debate that could be a good way to address this issue.

- The process should be ongoing.

4. Promoting tools and approaches fostering public engagement and co-ownership like crowdfunding
   - The participation process should create a proactive transversal informed dialogue with clear rules with all the relevant stakeholders, adapted to the territory, not only "addressing concerns" but presenting all the project dimensions and other energy options (their advantages, disadvantages, implementation on specific territories). This may be the way to create a consensus for geothermal energy development.
   - It is important to move beyond social acceptability, towards a paradigm of co-ownership. Emerging approaches like crowdfunding[27] can help in that respect.

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Chavot Philippe, Masseran Anne, Bodin Cyrille, Serrano Yeny, Zoungrana Jean, « Geothermal energy in France. A resource fairly accepted for heating but controversial for high-energy power plants », In: Manzella A., Allansdottir A., Pellizzone A. (eds) Geothermal Energy and

A "package permit" is available (comprising environmental and exploitation authorizations and concession). It is based on "variable features" (number, power, location of wind turbine) that constitutes the borders within which the project can evolve without having to submit new authorizations. Maximum potential negative impacts are taken into account to realize the Environmental impact study. The impact study can be realized by the ministry in charge of energy itself. This documentation is the base of the PI and an innovative way to foster public participation was put in place (see here, in French).
The "variable features" may be an interesting way to draw people's attention on the fact that, at the beginning of a project, some parameters remain to be decided.

[27] https://www.crowdthermalproject.eu/

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Annex

Collected and organized data and information

Seismicity data collection

Table 1

	France/Alsace	Germany /Palatinate	Swiss
National or regional framework	Regional	Regional	Cantonal
Authority	Local mining authority	Local mining authority	Local mining authority
Regulation	Prefectural decree	DIN 4150	ETH Guideline
Mandatory	Yes	Yes	Recommended, category III for traffic light system
Seismic network technical requirement	- Real-time data monitoring - 4 short period velocimeters - 1 “multi-sensor” station including a broad-band seismometer, an accelerometer, a GNSS receiver and a corner-coin reflector	- One network designed with four velocimeters according to the DIN 4150 (on buildings) - One real-time network, that could use both accelerometers or velocimeters; - number (generally 4 stations) and kind of stations of this network needs to be coordinated with the mining authority	- Real-time data monitoring - Shallow borehole (80-150 m depth) - At least 3 stations around the project - One station in the centre of the network equipped with an accelerometer - 3 orthogonal components for all stations
Seismic network installation	6 months before starting drilling	3 months before or at least if drilling starts	6 months before stimulation
Public data	All data from the “multisensor” station	All data from the velocimeters used to monitor the DIN 4150	Possibly all data

Organization collecting public data	ReNaSS (French seismic monitoring network)	The local (normally state operated) seismic observation network	SED (Swiss Seismological Service)
Definition of threshold	Yes	Yes	Yes
Physical value used for defining thresholds	PGV	PGV	M_L and PGV
Number of thresholds	3 thresholds (measured on 2 stations): - 0.5 mm/s, close monitoring - 1.0 mm/s, short term reduction in flow - 1.5 mm/s, stop operation	5 thresholds (measured on 1 station only): - 0.2 mm/s daily reporting - 0.5 mm/s short term reduction in flow - 1 mm/s long term reduction in flow - 5 mm/s operate at minimum flow - 10 mm/s stop operation	To be defined with local mining authority
Reporting to the mining authority	Before drilling: Report on natural seismicity Drilling: Monthly Testing: Daily Operation: Monthly	Before drilling: Report on natural seismicity and a seismic hazard analysis Testing: Daily Operation: Monthly	To be defined with local mining authority

Table 2

	Italy[28]	Belgium/Flanders	Iceland
National or regional framework	National / Regional	Regional	National
Authority	National (MATTM, MISE), Regional Mining authority	Regional authority VPO (Flemish Planning Bureau for the Environment and Spatial Development)	Orkustofnun
Regulation	National and regional regulations, National guidelines for geothermal projects, and Regional authority/company agreement	Decree of 8 May 2009 regarding the deep subsurface and the Decision of 15 July 2011 regarding the implementation of the Decree regarding the deep subsurface.	OS-2016-R01-01
Mandatory	Yes	According to art. 63/10 of the Decree, the concessionaire shall take all measures that can reasonably be expected of him to prevent the activities covered by the license from causing damage due to ground movements.	Yes

[28] MATTM: Ministry for Environment, Land and Sea Protection; MISE; Ministry of Economic Development; ARPA: regional agencies for the environmental protection (e.g. ARPAT is the Tuscany's ARPA)

Seismic network technical requirement	- Natural seismic background prior to exploitation - Real-time data monitoring - Local monitoring with company seismic network - Number (>2. 46 in Tuscany) and characteristic of the local monitoring network are to be coordinated with the local authority. National guidelines prescribe: - Stations able to detect $0 \leq M_L \leq 1$ MEQs inside the survey domain - A 3-components seismometer per station - At least a 3-component broadband sensor - At least one accelerometer may be prescribed for the operation phase - Data sampling frequency of at least 100 Hz (accelerometer) and 200 Hz (seismometer)	Specific measures can be imposed by the Flemish Government as part of the license (art. 63/14 of the Decree). Currently, the Balmatt project in Mol has real-time monitoring with 7 downhole sensors (see https://vito.be/en/vito-seismometer-network-investigates-earthquakes)	If the results of a preliminary assessment or research show a risk detectable earthquake activity is important to set up a sensitive metering system that records and locates an earthquake automatically as near as possible in real time. However, the installation and design of the earthquake measuring system must always take account of the circumstances.
Seismic network installation	12 months before starting "harnessing and reinjection", ending 1 year after the end of operation EIA is requiring 12 months before drilling in all current cases	Own network installed after drilling but prior to start-up of operations. The network includes two seismometers owned by NIRAS that were operational before the start of the drilling activities.	before discharge begins, if required
Public data	Only data from the national network	The sensor data are available for the Royal Observatory of Belgium (ROB)	SIL network Iceland Meteorological Office

Organization collecting public data	INGV (data from national network)	Royal Observatory of Belgium (ROB)	Iceland Meteorological office
Definition of threshold	No thresholds were defined by authorities, they may be defined for specific projects	No thresholds were defined by authorities	Yes
Physical value used for defining thresholds	M_L, PGV and PGA	No a-priori thresholds defined by authorities, but proposal from the operator was used (hence project specific). Initial threshold values were defined but adjusted as data were obtained and the network performance was appreciated. Initially, M_L, PGA, location, and # events per time unit were used. PGV has been added later on.	Mw, PGV
Number of thresholds	To be defined with local (Region) mining authority	2 thresholds (traffic light system with green-orange-red), but this system and the threshold values are project-specific. It was defined by operator and proposed to authorities. Changes are proposed to and discussed with authorities.	Not defined.
Reporting to the mining authority	To regional authority: at least twice a year, to be defined with local mining authority. In Tuscany every 3 months To national authorities (MISE, MATTM, ARPA): yearly, before, during drilling, testing and during operation	Operation: A yearly reporting is required in with an overview of seismic events related to the geothermal operations	National Energy Authority of Iceland. Assessment report before operation starts. Operator warns relevant authorities if reinjection might induce seismicity.

Aquifers' interferences data collection

Table 1

	Belgium-Flanders	France	Hungary
National or regional framework	Regional	National and regional [meaning it can differ from one region to another and can be specific to each site, so it can differ within the same region e.g. the regulation in Ile de France is more protective for an installation in the Albien, aquifer which is a strategic reserve for drinking water]	National
Authority	VMM - Flanders Environment Agency	Deconcentrated mining authority	Directorate General for Disaster Management and its regional offices (although authority work is performed at regional level, but they work according to the same national legislation)
Regulation	Decree containing measures regarding groundwater management (January 24, 1984) Appendix 5.53.1 of Vlarem II, Code of good practice for drilling and for operating and closing wells for groundwater extraction.	National level: Mining code, the law of December 16, 1964 on the regime and distribution of water and fight against pollution, the law of January 3, 1992 on water and the law of December 30, 2006 on water and aquatic environments, the decree n°2019-1518 of 30 December 2019 and the norm AFNOR NF X10-999 of August 30, 2014 on creation, monitoring and abandonment of underground water exploitation and surveillance wells, and mining and work titles	Act LVII. of 1995. on Water Management Governmental Decree 219/2004 (VII.21.) on the protection of groundwaters KvVM /Ministerial Decree 30/2004 (XII.30.) on certain rules of examination of groundwaters KvVM /Ministerial Decree 101/2007 (XII.23.) on intervention into groundwater resources and rules on drilling wells

Mandatory	Mandatory to drill in accordance with the code of good practice to prevent interaction with groundwater during and after drilling. Any deviation from the principles describe in the code of good practices must be argued and justified. They are described in the EIA.	Yes	Yes
Containment of physical (P-T) interference plan	Exclusion of interference with aquifers crossed during drilling	Exclusion of interference with aquifers crossed during drilling	Exclusion of interference with aquifers crossed during drilling

Prescription	Follow the code of good practice for drilling (Vlarem II, Appendix 5.53.1)	Regional: - Installation of monitoring wells or access to existing, suitable wells for monitoring -Groundwater quality monitoring -Special casing completion for groundwater -Casing and cementation inspection log after drilling -Injection well inspection log every 3 years in operation -Production well inspection log every 6 years in operation - On site corrosion monitoring - Monitoring of cement plugs and work to decommission the well during abandonment phase - The tubing and cementation control elements are provided to deconcentrated authorities (DRIEE/DREAL) or ministry depending on the permitting type. If non-compliant, work over can be imposed to operators - Specific controls can be edited when issuing the permit if need be (more frequent control due to high fluid mineralisation for example)	KvVM /Ministerial Decree 101/2007 (XII.23.): Avoid interconnecting different aquifers during drilling Casing and cementing of non-targeted aquifers during drilling Details of required measurements after the well is completed, listed in Annex I. Measurements recommended or compulsory depending on depth: shallower or deeper than 500m. Compulsory include: -acoustic, density or natural gamma for the cement integrity -borehole diameter -electric or acoustic to test the exact locations of the screens -flow and temperature measurements at closed conditions -capacity testing at 80%, 60% and 40% production rates -measurement of pressure increase (after max production testing)

Monitoring requirement	Not required	Regional: Piezometric network installed in strategic aquifer around the site to monitor water quality 1 upstream and 2 downstream wells (e.g. Alsace) If the risk is clearly identified, existing piezometric network are generally considered to monitor water quality around the site	In case of active/operating thermal water wells yield, pressure at wellhead, piezometric level and temperature has to be measured at least once a day (preferably digitally), in inactive wells at least once a week. For piezometric levels the reference (m asl) has to be provided. In addition, monthly measurement should include: cumulative produced amount, production time, well maintenance operations (if any happened)
Network installation or monitoring starting period		Before drilling	During operation

Public data	Once the well has been completed, a drilling report must be submitted to the authorities. The drilling report contains the administrative data of the drilling (client, location, ...) as well as the execution method and materials and techniques used. The drilling report includes the lithological information. The well schematic shows the complete installation of the well with the materials, diameters and depths used.	No. Data are only released to the local mining authority For the geothermal operations targeting the Dogger formation in the Paris basin, production and test data are centralised in a database edited by the BRGM (SYBASE). This database is addressed to operators only and is accessible for them through restrictive access. End of work reports (DOE) transmitted to the authorities at the end of drilling period and after work overs are public	A "Hydrogeological log-book" is compulsory for practically all wells (except for some very shallow and minimal production), the content and formal requirements of the log book are specified in Ministerial Decree No. 101/2007. as well as in MSZ15298 standard. According to the Ministerial Decree No. 101/2007., the Department of Hydrogeology of the Mining and Geological Survey of Hungary has been responsible for issuing hydrogeological log-books of new wells, maintaining the National Well Cadaster and operating the National Hydrogeological Archive since 2017 July 1, where all data are public. Monitoring data (measured by the operators) have to be submitted to the competent regional branch of Disaster Management
Organization collecting public data		-	Mining and Geological Survey of Hungary

Definition of threshold	Not relevant	Depend of the initial state	Not defined at local (well) level), but at the level of groundwater bodies (in line with the Water Framework Directive 2000/60/EC): according to Governmental Decree 219/2004 (VII.21.) a groundwater body is in good quantitative status if the long-term (min. 6 years) annual abstraction rate does not exceed the available groundwater resource, abstraction does not cause a permanent decrease in groundwater level or hydraulic head, water abstraction cannot exceed the so called "abstraction limit value (Mi)" which would ensure that abstractions do not cause permanent drop in the groundwater table / hydraulic head and do not result the mixture of other surface or subsurface waters causing unfavourable changes in quality. However, the determination of the Mi values –although prescribed by the law - for the groundwater bodies still has not happened in practice.
Physical value used for defining thresholds	Not relevant	Temperature, conductivity, radium 226 and uranium concentration	not relevant
Number of thresholds	not relevant		National

Frequency of reporting to the authority	-	4 time a year during drilling, Once a year in operation	Directorate General for Disaster Management and its regional offices (although authority work is performed at regional level, but they work according to the same national legislation)

Table 2

	Iceland	Italy	Turkey
National or regional framework	National	Regional. To be established if it is also National for Pilot Plants	National
Authority	National Energy Authority	Regional: President of the Regional Government / National: Government – Ministry of Economic Development MISE - Ministry for Environment MATTM (Pilot Plants)	
Regulation	Act on survey and Utilization of ground Resources 57/1998 requires utilization to be sustainable and environmental effects to be minimized	National / Regional	The only statement is the article stated in geothermal law requiring mapping of aquifers (reservoir for drilling and agricultural watering) and showing these areas within the geothermal exploitation license area.

Mandatory	Yes	During operation (for pilot plants): requirements are not set by regulation, but are always included in the permission to run the plant and in the approval of the EIA During drilling (for pilot plants): in case of need to use (pump) underground water, it is mandatory by regulation to provide a hydrogeological report explaining how interference with aquifers is avoided. In some case, in the approval of the EIA, pressure control in monitoring wells has been required for drilling, regardless of the need of underground water. In general, requirements are settled by EIA with definition of specific prescription, both for drilling and operation. A plan for well cementing in regard of expected lithology and hydraulic condition is included in the EIA and evaluated and authorized by mining regional authority	
Containment of physical (P-T) interference plan	Defined in utilization licences	Exclusion of interference with aquifers crossed during drilling	

Prescription	Defined in utilization licences, PT is monitored as well as water level. Environmental monitoring such as chemistry is also mandatory. For each case the monitoring may differ, depending on the situation. Operator conduct several tests such as environmental monitoring and technical aspects. The local health authorities monitor ground water and surface impacts.	Prescription defined by EIA - Control of piezometric level and temperature (only if prescribed, in particular case) - Monitoring of water sources and surface water - Control of the cementing efficiency	
Monitoring requirement	Defined in each licence limits on utilization rate of the geothermal reservoir and draw down.	During drilling: - Periodic self-control of piezometric levels at wells. - EIA may require spot control of piezometric levels and cementing procedure (regional agencies for the environmental protection ARPA) During operation (for Pilot Plants): - Periodic self- control of piezometric levels at wells. EIA may require spot control of piezometric levels from authorised personnel (regional agencies for the environmental protection ARPA) Monitoring requirement are in general defined in EIA, where a piezometric network can be prescribed to monitor water quality and piezometric level around the site	

Network installation or monitoring starting period	Network needs to be sufficient to comply with licence conditions. and installed prior to production	Before and during drilling Before and during plant operation	
Public data	Currently not published, can be confidential for up to 5 years	No. Data are only released to the regional authorities (regional agencies for the environmental protection ARPA and Regional Hydrogeological Survey)	
Organization collecting public data	National Energy Authority	-	
Definition of threshold	Not relevant	No. Details of control are set within the permits' prescriptions depending on local characteristics of the aquifers	
Physical value used for defining thresholds	Not relevant	-	
Number of thresholds	Not relevant	-	
Frequency of reporting to the authority	National Energy Authority at least once per year. Both in drilling and operation.	To regional agencies for the environmental protection ARPA Reporting frequency, both for drilling and operation phase, depends on the prescriptions defined for monitoring requirements based on local characteristics of the aquifers.	

Aeriform emission data collection

Table 1

	Belgium/Flanders	France	Hungary
National or regional framework	Regional	National and regional [more protective for the territories where it can be an issue, e.g. Guadeloupe and Alsace]	National
Authority	Flemish government the minister has to approve	Deconcentrated mining authority	Environmental Authorities form part of the Regional Governmental Offices, as divisions for Environmental and Nature Protection
Regulation	VLAREM II Section 2.5 Environmental quality norms and target values for air and the assessment and management of air quality. Section 4.4 Management of air pollution, target values and measuring methods for high risk activities. Part of the exploration license	Ministerial decree 80-331 on General Regulations on Extractive Industries, article 42 & 46 (focus on drilling) Articles RG29 and RG30 of the General Regulation on Extractive Industries Drilling permit (Prefectural decree) Exploitation permit (Prefectural decree)	Ministerial Decree 12/1997 (VIII.29) on the degasification of produced waters
Mandatory	Yes	Yes	Yes
Containment of emission plan	Yes	Yes	No

Prescription	- mitigation measures have to be reported - coproduction of substances has to be reported yearly - periodic measurement of the gas content (but frequency is not mentioned) -	National: - The drilling rig must be equipped with a degassing system, a torch and H_2S and CH_4 monitoring, site manager then applies the appropriate safety instructions Exemption possible if safety is proven - In case of radionuclide risk, atmospheric monitoring, including radon during operation Regional: - In case of H_2S risk during operation, onsite monitoring, and annual campaign around the plant - Monitoring through physico-chemical parameters and chemical composition once a year during operation	Gas analyses have to be done: • during drilling • renovation/ cleaning of the well • during operation at frequency as defined in the operational license (individual) Produced thermal waters are classified into 3 categories according to their measured gas content at 1013 millibar pressure and at 20 °C temperature: - "A" below the threshold of 0,8 l/m^3; - "B" between 0,8-10 l/m^3; - "C" above 10 l/m^3. The Decree describes in details the procedure of analyses, which can be done only by nationally accredited laboratories. The analyses are pre-requisite to get an operational license for water wells. Degasification at wells is compulsory in water falling into" C" category applying a MSZ-10-226 certificated degasifying unit. In "B" category the degasification has to be done under the normal operational circumstances, while in category "A" it is not required. The degasification has to be done in a way that it does

			not cause the deterioration of water quality.
Monitoring	no monitoring network for the gas composition -	Continuous air quality monitoring during drilling at 1 fixed station on the drilling site If H_2S is a risk during operation: - Continuous air quality monitoring during operation at 1 fixed station - Air quality monitoring campaign during operation around the plant (number of stations not fixed) If radioactivity is a risk, campaign on 2 stations around the plant	The gas content has to be regularly monitored with repeated analyses: in category “A” – every 5 years, in category “B” – every 3 years, in category “C” – every 2 years.
Network installation		Prior to starting drilling activities, devices for H_2S and CH_4 detecting must be installed on the drilling rig. At the beginning of plant operation if H_2S is a risk	

Public data	In general, for industrial activities emissions are being reported to the Flemish Environment Agency (VMM) https://www.vmm.be/data. But the licence for Balmatt also refers to the Department of Environment & Spatial Development.	No public data (The only source of (limited) information is the Non-Technical Summary of the Environmental Impact study during the public enquiry).	After drilling is completed, gas measurements form part of the Hydrogeological Log Book, which (since 2017) is prepared by the Mining and Geological Survey of Hungary. Hydrogeological Log Books are publicly available in the National Hydrogeological Archive Gas measurement during operation is done by the operators, data are submitted to the Regional Governmental Offices. These are not public
Organization collecting public data	Flemish Environment Agency (VMM) - https://www.vmm.be/data	-	Mining and Geological Survey of Hungary (National Hydrogeological Archive), operators and Regional Governmental Offices
Definition of threshold	Yes, for both air quality and for emissions at plants	Yes, for air quality only	0,8 and 10 l/m^3 (thresholds of the different categories) No air quality specific threshold for geothermal energy, beyond national regulation of general application
Physical value used for defining thresholds	Concentration in air	Concentration in air	Concentration of dissolved gas in the produced thermal water

Number of thresholds	Air quality	- Onsite limits: max 10 ppm during 15 min or average 5 ppm during daily time (8h/day and 5 day/week) - Outside toxicological reference limits: 93.75 ppm for acute inhalation (WHO) and 6.25 ppm for chronic inhalation (OEHHA)	
Frequency of reporting to the authority	Yearly report to VPO (Flemish Planning Bureau for the Environment and Spatial Development) as part of the exploration license (occurrence of hydrocarbons and other substances that are coproduced with the geothermal water).	H_2S and CH_4 during drilling: daily and at the end of drilling operation to the local mining and environmental authority If H_2S is a risk during operation, annual reporting to the local mining and environmental authority If radioactivity is a risk during operation, annual reporting to the local mining and environmental authority Annual geochemistry (including H2S) reporting to the local mining and environmental authority	After well is completed, during operation according to categories: category “A” – every 5 years, in category “B” – every 3 years, in category “C” – every 2 years

Table 2

	Iceland	Italy[29]	Turkey
National or regional framework	National	National/Regional	National
Authority	Ministry for the environment and natural resources	National: a) legislation: (Ministry for Environment MATTM, Ministry of Economic Development MISE) b) support and enforcement (SNPA. CUFAA, ISS); /Regional: a) legislation: Regional government, Local authority; Enforcement: ARPAT	Ministry of Environment and Urbanization
Regulation	514/2010 Regulation on the concentration of hydrogen sulphide in the atmosphere.	National and regional regulations, National guidelines for geothermal projects	No legislation specifically designed for geothermal applications; however Environmental Law; Official Gazette Date: 03.07.2009 No: 27277 is implemented
Mandatory	Yes	Yes	No (Power Plant operators are implementing requirement of above stated law in practise)
Containment of emission plan	Yes	Yes	No

[29] MATTM: Ministry for Environment, Land and Sea Protection; MISE; Ministry of Economic Development; SNPA: National System for Environmental Protection; CUFAA: Nucleo Operativo Ecologico dell'Arma dei Carabinieri; ISS: National Institute of Health; ARPA: regional agencies for the environmental protection (e.g. ARPAT is the Tuscany's ARPA)

Prescription	Provisions for operating licenses for business operations that may cause H_2S-related pollution shall take appropriate measures to prevent air pollution caused by it and shall apply the best available technology (BAT) and any additional measures where necessary. During drilling emissions are monitored for safety of workers	During plant operation National: - Predictive modelling of emission effects - Monitoring and abatement plans Regional (Tuscany): - Public Access to environmental information - best available technology (BAT) enforcement - Emission limits - max number of non-operational hours for abatement systems - target emission levels for new/revamped systems	Reporting data to City Governments on monthly basis

Monitoring	Where it has been demonstrated that a metering station is required for a local source, the inspector may require the installation of a metering station, and the business operation caused by the pollution shall cost the installation and operation of the metering station. The monitoring body concerned monitors the measurements and handles the measurement results. Measuring devices shall collect at least 10 minutes of average hydrogen sulphide concentration in real time by the power plant and in neighbouring communities	- Continuous air quality monitoring during drilling and operation - Spot monitoring of air quality (including noise) - Periodic data monitoring at emission sources (ARPAT) - Continuous air quality monitoring at 1 fixed station in the area (ARPAT) - Spot air quality measurement at variable location (2 mobile labs, ARPAT) - Continuous (daily average) operators' self-monitoring of air quality at 18 fixed stations (EGP) periodically validated by ARPAT - Continuous self-monitoring of plant operation, remotely accessible by regional authorities (for new plants only since 2019)	Periodic recording being performed by operators
Network installation	Variable between licences Generally, at the beginning at plant operation.	Before the beginning of plant construction. During drilling: only safety procedures for working personnel. During construction phase of drilling pad (spot monitoring).	At the beginning of plant operation During drilling: only safety procedures for working personnel
Public data	Public access to information on environmental matters that is collected by public authorities	No public data related to the drilling phase. All data, public access is granted by law (ARPAT's periodic reports available on the website)	Public access is under the decision of City Governments

Organization collecting public data	National Energy Authority, Local health authority, Environmental agency of Iceland, Municipalities.	ARPAT, Regional Authorities	Operators, and Environmental and Urbanization Ministry
Definition of threshold	Yes (air quality)	Yes, for both air quality and for emissions at plants	Yes, for both air quality and for emissions
Physical value used for defining thresholds	Concentration of H_2S in the atmosphere	Concentration in air, concentration at plants' emission sources	N/A specific for geothermal power plants
Number of thresholds	1 (H_2S)	During operations: Air quality: 6 (H_2S, As, Hg, B, NH_3, Sb) At emission sources: 3 (Hg, H_2S, SO_2) at AMIS outlet. Additional 3 thresholds are recommended in new plants (As, NH_3 and H_3BO_3)	1 (H_2S)
Frequency of reporting to the authority	At well test accomplishment (for CO_2, H_2S and CH_4) During operations: Yearly	During operations: - twice a year for each plant to regional authority (emissions) - Continuous reporting on plant and abatement system availability to regional authorities - Monthly reporting on air quality data to ARPAT - Reporting on specific air quality campaign due to prescriptions	Data reported to City Governments on monthly basis.

Discharge of geothermal fluids data collection

Table1

	Belgium - Flanders		France	Hungary
National or regional framework	Regional	Federal/Regional	National / Regional	National
Authority	Public Waste Agency of Flanders (OVAM)	Federal Agency for Nuclear Control (FANC)	Local mining authority	Regional offices of Disaster Management
Regulation	The waste generated on the site must be removed and processed in accordance with … Materials Decree: https://navigator.emis.vito.be/mijn-navigator?woId=41882 The Materials Decree is based on a comprehensive view of the material chain that is essential to find an answer to the waste issue. The decree anchors sustainable materials management in Flanders. The decree implements the European Framework Directive (EC) 2008/98 on waste management in Flanders. VLAREMA VLAREMA is the implementing decision that runs parallel with the Materials Decree. It contains more detailed prescriptions concerning (special) waste streams, raw materials, selective collection transport, registration duty and the extended producer responsibility.	Royal Order of 20-04-2001 concerning general regulations for the protection of the population, employees and the environment to the hazards of ionizing radiation (ARBIS) Order of the Flemish government of 28-10-2019	National: Ministerial decree 2006-649 Ministerial decree 14 October 2016, artic 17-2 Regional: Prefectural decree	Act LVII of 1995 on water management Governmental Decree 219/2004 (VII.21.) on the protection of groundwaters Governmental Decree 147/2010 (IV.29.) on the general regulations related to the activities and establishments serving the utilization, protection and mitigation of damages of waters Governmental Decree 220/2004 (VII. 21.) on the protection of surface waters KvVM /Ministerial Decree 28/2004. (XII. 25.) on the threshold values of water contaminating materials and on certain rules of their application

Mandatory	Yes	Yes	Yes	Yes
Prescription	Sustainable materials and waste management Liquid waste: discharge at surface, the operator must prove that he acts as a responsible person and that the quality of the water allows to be discharged at surface (which is not the case for deep geothermal water in the regions because of the chemical composition). So, in practice there is no surface discharge.	NORM waste (solid and liquid)	National: -Radionuclides Regional: - TSS, COD, THC - Temperature	the input of used and waters into water bodies – after a necessary treatment – can happen only in a way that does not threat the natural processes and the quality and quantity renewal of the water reserves. The thermal groundwater abstracted for energetic purposes may be reinjected to the same aquifer after utilization, but surface disposal/discharge is also allowed considering the amount and quality of the used thermal water, its impacts on the environment, the capacity of the surface recipient. if any of the components of the used thermal water are above the threshold values, then the thermal water has to be discharged into an artificial lake. In case the used thermal water and the cleaned water of the settlement have no harmful interactions, they should be drained together.

Monitoring requirement	The waste producer of industrial waste keeps a register of the waste produced. This contains the following information: • the amount of waste in tons, cubic meters, liters or kilograms • the nature and composition of the waste materials, including the EURAL code • the processing or application method of the waste materials: dumping, incineration with energy recuperation (R1), other waste incineration (D10), reuse, composting, recycling, sorting, other pre-treatment • if applicable, the name, address and identification number of the collector, waste trader or broker, of Belgian collectors, waste traders or brokers, the company number and of the foreign number • name, address and identification number of the processor of the waste, of Belgian processors the company number and of foreign companies the VAT number. A collection of identification forms can be used as a register of generated waste materials, supplemented with data on the waste movements for which no identification form is required or for which the waste producer itself makes arrangements. The register of waste generated is updated with the most recent data at least every month. The register is kept by the registrar for five years. The register is available for	- Monitoring is obligatory to the operator and periodic dose measurement of the surface installation is being performed. -Risk of NORM is to be evaluated in the EIA - NORM - file issued to FANC - Regular consultation with FANC during project duration - Incidents are to be reported to the FANC	Sampling	defined in the operational licence

	inspection at the operating site.			

Network installation or monitoring starting period	N/A	VITO needs to perform periodic dose measurement of the surface installation. We have a measurement plan and the locations where we will measure are marked on the installation. Measurements are compared to the maximum radiation dose, but also relatively to previous measurements. ***Monitoring frequency*:** 0) Zero measurement on the tube 1) 2 weeks after the start of circulation; Additional measurements on these filters may therefore be necessary. 2) 1 month after measurement 2 3- depending on the results 2 months after measurement 3 The measurements that follow will be taken over an interval of 2 to 3 months, unless large differences in dose flow are observed in a short period of time. If little dose flow is measured, it is possible to switch to statistical measurements. Manual measurements will be taken every six months.	None	Depending on prescriptions, case by case

Public data	OVAM lists a number of figures each year. https://ovam.be/feiten-cijfers ed specific information on waste from geothermal sites	No public data, the data are provided to the federal authorities	No, Data provided to the local mining authority	No, they are provided to authorities
Organization collecting public data	OVAM	FANC	-	Regional Directorates for Water Management
Definition of threshold	No threshold to my knowledge	Threshold is determined by the authority and linked to the specific radioactive isotope.	Yes, Concentration of pollutants regulated by national/regional laws	Decree 28/2004. (XII. 25.) contains provisions on the threshold's values of various contaminating materials in different fields. Chapter 34 specifies threshold values for thermal water discharge into surface recipients (e.g. rivers, streams) in 3 categories: medicinal, balneological, and energetic. The highest allowable threshold values are provided for the medicinal utilization (5000 mg/l) thus appreciating its economic and public health value, while lower values are allowed for balneological (2000 mg/l) and energetic (3000 mg/l) utilization (. The allowed heat load is 30 °C in all 3 categories (i.e. this is the maximum allowed temperature at which thermal water can be released at the surface).

Physical value used for defining thresholds	-	Bq/l for ^{226}Ra	TSS, COD, THC, Temperature, radium 226 and uranium concentration	mg/l
Number of thresholds	Defined case by case according to the characteristics of waste	1 threshold 3.6 Bq/l for ^{226}Ra	Total suspended solids (TSS): < 35 mg/l Temperature: 30°C Chemical oxygen demand (COD): < 125 mg/l Total Hydrocarbon Content (THC): < 10 mg/l	Temperature: 30°C for disposal at surface TDS: 5000 mg/l (medicinal water), 2000 mg/l (balneology), 3000 mg/l energetic use
Frequency of reporting to the authority		FANC The measured values are kept in a register and are reported as soon as data from a measurement campaign is available.	Once a year	-

Table 2

	Iceland	Italy	Turkey
National or regional framework	National	National / Regional	National (applicable only for drilling operations)
Authority	Ministry of environment and natural resources	National: a) legislation: (Parliament, Head of Government, Ministry for Environment) b) support and enforcement (SNPA). Regional: a) legislation: Regional government, Local authority; Enforcement: regional agencies for the environmental protection (ARPA)	Ministry of Environment and Urbanization
Regulation	regulation nr. 550/2018	National: Framework Laws (from EU directives) and ministerial decrees; Regional: regional laws and applicative regulations	a) Environmental Impact Assessment (EIA) Regulation (Official Gazette Dated: 25.11.2014 No: 29186 b) Mining Waste Regulation (Official Gazette Date: 15.07.2015 No: 29417)
Mandatory	Yes	Yes	Yes

Prescription	Covers all waste from business and industry	National: Liquid waste not dischargeable to surface / UG (underground) water: application of the reduction, reuse, recycle principles - segregation of waste, proper management and disposal to authorised treatment plants only, reporting of dangerous waste production to authorities Regional: Liquid phase of geothermal fluid reinjected in original geological formations. Reinjection must be authorized by Regional Authorities	no prescription The regulation is excluded from the geothermal scope in the definition of mine. Equally, since the Circular No: 2012/15 on the Disposal of Waste Resulting from the Physical Processing of Drilling Muds and Chromium has been repealed, which was previously in force for the disposal of drilling muds, no method is currently defined in the legislation for disposal of drilling muds. A clause on the disposal of drilling waste is required to be added to the Mining Waste Regulation.
Monitoring requirement	Permit issued by local health authority that details the conditions for release of waste. Local health authority monitors the compliance to the licence.	Internal management plan at facility, accountancy and reporting to authority.	No regular monitoring implementation
Network installation or monitoring starting period	As needed in order to comply with permits	None Spot monitoring of reinjected geothermal fluid with ARPAT	N/A
Public data	All data can be accessed according to 140/2012. Some data is published online by authorities	Data have to be provided to regional authorities (not to be published entirely).	N/A
Organization collecting public data	Environmental agency of Iceland and local Health Authorities	In case of liquid waste (e.g. exhausted drilling mud): “Chamber of Commerce”; Reinjection of liquid geothermal phase: ARPA / Regional authorities.	N/A

Definition of threshold	All waste is included, threshold is determined in each permit	none	Concentration of pollutants regulated under EIA and upper limits are defined through the legislation
Physical value used for defining thresholds	See above		Usually mg/kg or mg/l
Number of thresholds	Not relevant	-	Nothing specifically defined for geothermal drilling
Frequency of reporting to the authority	The Environment Agency shall determine the frequency of periodic maintenance and supervision in operating licenses.		N/A

Complex licencing and delays data collection

Table 1

	Belgium	France	Hungary
Type of permits	*Flanders:* Exploration Production Environmental *Wallonia*: The foreseen subsoil decree defines the exclusive exploitation and exploration permit. Currently, unique permit is required.	Exploration: AR or PER based on petitioner's choice Exploitation: Permit or Concession depen ding on primary thermal power Work permit (cf. drilling or Operation Permit)	Water license <2500 m (preliminary, construction, operation) Concession >2500 m Heating plant (e.g. DH license) Environmental permit
Permit duration	*Flanders*: 5 years (exploration license) *Wallonia*: The foreseen subsoil decree defines 7 years exploration license.	Exploration 3 – 5 yrs Open	Water licence: 5 years Concession: 35 years
Authorities	*Flanders:* EIA office Environment department	Local deconcentrated Authority (Prefecture with local mining authorities (DREAL)) Central Authority (Ministry)	Regional Directorates for Disaster Management (Water license) Mining Authority (Concession) Environmental authority (involving relevant other authorities)
Timing of permit application	*Flanders:* Environmental permit: 150 days EIA: >100 days (subject to developing the EIA) Exploration permit: 90 + 120 days (subject to competition) *Wallonia*: The foreseen subsoil decree defines the timing.	Exploration: - AR: 18 months administration, silenc e implies refusal - PER: 2 years administration, silence implies refusal Exploitation: Permit: 18 months administration silenc e implies refusal Concession: 3 years administration, silence implies refusal	Water licensing: 45-60 days after submission of documents, Concession: 1-2 years

Are the timings foreseen by the regulation adequate?		PER: 2 years Concession: 3 years Drilling: 18 months * The timings for permit instruction are too long	Yes
Do (extreme) delays often occur? Can you give examples?		Due to the current decrease of the mining activity in France (oil, gas, minerals…), there are less competent and experienced people within the public administration which increase the delays of instruction Maximum legal timing is foreseen as the standard practice When several geothermal projects are considered too close spatially, an interference study in terms of thermal, hydraulic and induced seismicity is asked by the local mining authorities. Thus, it could generate additional delays up to 9 months. When the legal timing for the instruction is over and the instruction is not over, the petitioner can ask to the authority extra time	Delays can especially happen when the thermal water well is deeper than 2500 m, i.e. the permitting authority for concession is the Mining Authority, however, the Directorates for Disaster Management (as water authority) are also involved. The communication between the 2 authorities is not always smooth, especially because they belong to different ministries. A general comment from the stakeholders is, that especially the operating permits are delayed, because the permitting authority is asking other co-authorities' (i.e. construction) statement, which is time consuming

What are the main reasons for these delays?		Competent and experienced human resource missing in ministry and in local deconcentrated Authorities. For some technical issues, external expertise is sometime required and can induce additional delays	Administrative and technical complexity: requiring the licence for water production from the Regional Directorates for Disaster Management can happen through very complex forms, which contain many unnecessary administrative data. Furthermore, many technical details are also requested, i.e. water analyses, etc. Due to the complexity of the forms, the authority is almost always asking to provide additional corrections (during corrections the timing for application is pending, i.e. this adds to the normal time foreseen). Many applicants submit incomplete licensing documentation, or in poor quality (most often because they are under the pressure of some deadlines, i..e. the pre-requisite of funding is a valid preliminary permit)
Which regulations or standardized procedures exist in your country that are helpful to avoid delays?		A special procedure can be applied to combine the demand for Research authorization and for the work permit or the demand for the exploitation permit and work permit (especially done in the Paris basin, where the geological context is well known)	The exact form of water licenses (content, structure, etc.) is prescribed by law (41/2017 (XII.29.) Ministerial Decree
Which regulations or standardized procedures would be helpful in your country to avoid delays? (add source to good practice if applicable)		One-stop shop at national level, with mining skills and knowledge of the territory, to manage all mining authorizations Applying to the mining activity the ICPE procedure, which is well managed by the local deconcentrated Authority	Although in theory the licensing is a “one-stop-shop” (i.e. applicant has to submit the request to one authority), in practice the involvement of many co-authorities makes the procedure time consuming and unnecessarily complex

Table 2

	Iceland	Italy	Turkey
Type of permits	The master plan, planning, EIA, Construction licences, Research, Prospection, Utilis ation (Resource Act) Power plant (Electricity Act)	Exploration Permit (EP) Mining lease/Concession Exploration (pilot plants)	Exploration Exploitation Generation Various other licenses for power plant (construction, zoning, water works)
Permit duration	Varies between licenses. Up to 65 years.	Exploration: 4 +2 yrs Mining:30 yrs (exception for titles 2010)	Exploration: 3 + 1 yrs Exploitation: 30+10 yrs
Authorities	The master plan: the national parliament, planning and EIA (the planning agency), construction licences (local municipalities), Exploration-utilization and powerplant licences (Orkustofnun)	EP: Competent Region (and the provincial authorities of Trento and Bolzano) EP-pilot: Ministry of Economic Development (MiSE) Ministry of Environment and Protection of Land and Sea (MATTM) Concession: Relevant regional administration (or MiSE in case of off-shore resources and pilot plants)	YİKOB (Investment Monitoring &Coordination Departm ent EMRA (Electric Market Regulatory Authority; for power production) Environment Ministry, EIA Department
Timing of permit application	Master plan: supposed to be renewed every 4 years (but has been delayed), EIA-no timeframe, NEA Licensing: 3-6 months depending on the situation	EP: 240 days starting from the date of the submission (exc. time for EPS – 90 days) Mining: 220 days (exc. time for EIA - 150-330 days)	Exploration license: 5 days Exploitation license: 15 days Power generation pre license: 40 days EIA: 1 year Power generation license: 70 days
Are the timings foreseen by the regulation adequate?	No time limitation in most of the regulations	Regardless of exceptions, yes	No matter there are exceptions, in general, yes.

Do (extreme) delays often occur? Can you give examples?	The master plan has been delayed extensively. EIA can often take excessive time	Extreme delay occurs. No new exploratory well (outside the existing Enel concessions) has been drilled in Italy since February 2010 when the new Geothermal law came into force although many new research permits were released (more than 50). Only one concession was granted by Tuscany Region in an already explored geothermal field following a special procedure (Pilot Plant) but also in this case no wells have been drilled up to now	Lack of a central management and involvement of several authorities can create delays based on bureaucratic slowness.
What are the main reasons for these delays?	The master plan: political reasons For EIA and licences appealing process often takes a lot of time	Too many actors Bureaucracy (the present Italian law foresees two stage of permits both requiring an EIA procedure: the request of research permit or exploratory drilling and the request of concession to exploit geothermal resource. In this case not only the developers need two long procedures, but it could happen that developers receive green light for the exploratory drilling and red light for the concession) Technical complexity and lack of broad expertise in the reference offices	Too many actors involved in the application process Bureaucracy Social resistance
Which regulations or standardized procedures exist in your country that are helpful to avoid delays?	The public administration law (37/1993) Information act (140/2012)		Petition referring to reason of delay can be given to related authority, and the authority can grant an extension.

Which regulations or standardized procedures would be helpful in your country to avoid delays? (add source to good practice if applicable)	Timeframe for appealing processes and clearer timeframe in the master plan act.	To ensure that the durations of the authorization procedures comply with the time limits prescribed by law through the mechanism of silence / consent.	Establishing a central geothermal authority with assisting unites in geothermal regions.

EIA data collection

Table 1

	European Union[30]	Belgium	France
Regulation of the Environmental Impact Assessment			
What is the type of regulation that defines EIA in your context? (e.g. a national law, regional, sectorial conditions) **Please indicate if there are more than one regulation.**	Directive 11/92/EU as amended by Directive 14/52/EU	There is no national law, the EIA is regulated per Region, with Flanders the following decrees: - Decree of April 5, 1995 laying down general provisions on environmental policy, in its Title IV article 4.1.1 to 4.7.2., also called DABM sets the general EIA procedure - Decree of the Flemish Government of 10 December 2004 Decree of the Flemish Government laying down the categories of projects subject to environmental impact assessment - Flemish Decree of 8 May 2009 defines geothermal heat as subsurface heat generated by natural means or by heat storage	EIA is regulated by the national code of environment.

[30] Directive 2014/52/EU amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment. Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment

When is the EIA mandatory in your country for Deep Geothermal projects?	The EU directive foresees two types of procedure to assess environmental impacts of projects: a Mandatory EIA, and a Screening procedure: Mandatory EIA: The project listed in Annex I require a mandatory EIA as they are considered as having a significant effect on the environment Eg. Deep drillings, such as geothermal drilling is part to annex II, hence subject to an exemption from an EIA (see, Annex II, point 2, d, i)	The lists of activities subject to EIA can be found in annex I to the implementing order of 10 December 2004 (B.S. 17/02/2005). The initiator of the project needs to verify whether the activity subject to authorization must be subject to an environmental impact assessment. It is of his/her responsibility to know the regulations, and to look at the full project, see what is subject to EIA and what is not. It is applicable to all activities that might have an impact on the environment. Need to dive into the content of the appendixes to find out what is required for Deep DG. At this stage is Flanders, it cannot be concluded that the EIA is mandatory, given the novelty of the topic in the Region, and the specificities per project. The EIA is perceived as inadequate for deep geothermal projects. For the Balmatt project, an exemption could be asked on the basis of deep drilling, but the operators performed an EIA.	EIA is mandatory in the following case: - Research authorization - Authorization to Open Mining Works (drilling depth over 200 m deep) - Concession and authorization for exploitation - Activity classified as Installation Classified for the Protection of the Environment, example: Organic Rankine Cycle using explosive gas.

Under which conditions can competent authorities provide an exemption of the EIA for a Deep geothermal project?	Screening process: The projects listed in Annex II are left to the discretion of the Member States, which means that the national authorities are competent to decide whether an EIA is needed, through a "screening procedure", which "determines the effects of projects on bass of thresholds/criteria or a case by case determination"[31]. Article 4: "for projects listed in Annex II, Member States shall determine whether the project shall be made subject to an assessment in accordance with Articles 5 to 10. Member States shall make that determination through: (a) a case-by-case examination; or (b) thresholds or criteria set by the Member State. Member States may decide to apply both procedures referred to in points (a) and (b)." Annex III lists the selection criteria on a case by case examination.	Annex II of the Order of 10 December 2004 (B.S. 17/02/2005) lists the projects for which, in principle, an Environmental impact assessment report must be drafted, but for which the initiator may submit a reasoned request for exemption to the EIA office. The decision of 1 March 2013 added an annex III to the project EIA decision of 10 December 2004 , covering projects eligible for an EIA screening procedure. The general guideline on the screening procedure can be found on the website[32] of the administration of Environment.	Officially, for the PER (exploration) and the concession (primary thermal power > 20 MW), only "environmental impact statement" are required. In Alsace, the operators actually produce an EIA.

[31] https://ec.europa.eu/environment/eia/eia-legalcontext.htm. Consulted on 17 June 2020.
[32] https://omgeving.vlaanderen.be/sites/default/files/atoms/files/Handleiding_projectm.e.r.-screeningversiejuni2020.pdf

What are the main elements the EIA must include for a DG project?	The EIA has to identify and assess the direct and indirect effects on (Art. 4 to 10, annex IV): a) "human beings, fauna and flora b) soil, water, air, climate and the landscape c) Material assets and the cultural heritage d) The interaction between the factors referred to in a), b), c." Concerning impacts and risks, the information to be provided by the developer shall include (Art. 5(1) EIIA directive): - a description of the likely significant effects of the project on the environment; - a description of the features of the project and/or measures envisaged in order to avoid, prevent or reduce and, if possible, offset likely significant adverse effects on the environment; - a description of the reasonable alternatives studied by the developer, which are relevant to the project and its specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the project on the environment;	The content of an application is flexible, i.e. the content depends on the needs and complexity of the project. 3 trajectories are possible in the guideline provided by the Administration of Environment. The EIA report must include minimum : 1) Description of the project including the alternatives considered; 2) Existing permit status and permits to be applied for, 3) Proposal of the team of recognized EA experts and the recognized EIA coordinator including the division of tasks; 4) Description of the process (e.g. participation process, ...), 5) Description of the significant effects to be investigated that the project might have;5) Non-technical summary, mitigation measures, and alternatives. In practice, the operator needs to look at the full project and map in the regulations which aspects of the project can potentially cause harm and nuisance to the environment. For example, the EIA for the Balmatt project contains a description of the potential effects on 1) soil and underground water,2) noise and vibration, 3) water, 4) air, 5) people, 6) fauna and flora, 7) landscape, heritage and archeology, and the mitigation measures, monitoring and evaluation. The general guideline[4] to do the EIA is available on the portal of the Administration of Environment The main elements at this stage are quite generic and perceived as inadequate by operators.	Content of EIA is described precisely in article R.122-5 of the environmental code: a) A non-technical summary b) A description of the project c) A description of the initial state of d) A description of the human beings, fauna, flora, material assets and the cultural heritage e) A description of project's impacts f) A description of technical mitigation g) A description of compensation measures h) Monitoring implemented to assess impacts i) A description of method to assess j) A description of authors and experts involved in the EIA k) A Risk analysis in certain case

What are the main elements the screening procedure must include for a DG project?	A selection on criteria and or thresholds defined in Annex III.	The screening procedure concerns the projects the activities of which are included in Appendix III of the implementing order of 10 December 2004. Relevant criteria are based on the type of the project, the location of the project, and the type and extent of the potential environmental impacts. The guidelines of the screening procedure can be found on the website of the Environmental administration.	Impact assessment on air, soil, subsurface and underground water, human heath, fauna and flora, noise and vibration, and in some case on induced seismicity

The content of the EIA: defining thresholds and mitigation measures

Is there a dedicated guideline for EIA in your country? Does it include specificities on DG projects?	/	The EIA procedure is generic, and not specific to Deep DG at this stage. The EIA office supports in the assessment through provision of guidelines on specific topics: -the general methodological and procedural aspects (e.g summary of non-technological, mitigation measures, and alternatives in the EIA procedure)[33]; for the EIA procedure for projects (general EIA procedure and screening procedure, and environmental permit); for EIA plans; per discipline (Soil, water, biodiversity, landscape, architectural heritage and archeology, noise and vibration, air, people, light, heat and radiation, climate and security). It provides guidelines per group of activity, and interpretation manuals project-EIA decision. Different paths can be taken, concerning the drawing up of the EIA report. The different paths are described in a guideline document[34].	A guideline was published in 2017 by the Commissariat général au développement durable (CGDD, Environmental ministry) These guidelines include some specificity for oil, gas and geothermal drilling

[33] https://omgeving.vlaanderen.be/sites/default/files/atoms/files/rlb-alg-proc-en-meth-aspecten-2015.pdf
[34] https://omgeving.vlaanderen.be/sites/default/files/atoms/files/Handleiding_PR-MERinOV%20-%20actualisatie2020_def.pdf

Scope: **Is there a predefined list of impacts for DGE in the EIA guideline?** • **If so which environmental impacts and risks must be reported?** • **If not, how is it decided which impacts and risks are in scope?**	Annex IV, point 1, C): "an estimate, by type and quantity, of expected residues and emissions (water, air and soil pollution, noise, vibration, light, heat, radiation, etc.) resulting from the operation of the proposed project."	The initiator of a project when introducing the demand for an environmental permit, submit a file for registration, which must include, among other things, the potential effects on the environment and the related measures to mitigate the potential impacts. In that sense, the initiator defines him/herself the potential impacts on the environment. This registration is mandatory, and can be accompanied with a scoping advice provided by the EIA office. The scoping advise is not mandatory (art. 4.3.7 DABM). The more the file is complete when first introduced, the easier it is for the EIA to provide a scoping advice. The demand for advice is then transferred to the related governmental, administrative and public bodies, chosen based on where the project aims to take place and the potential impacts on the environment. The application (including Team Mer's decision and scoping advice) will be announced on the Team Mer website. The list of impacts to be studied is generic in Flanders. For example, the EIA office provided guidelines for the Balmatt site on: - Soil (versie 1.1., juni 2008); - Water (versie 1.0, juni 2011); - Fauna and Flora (versie 1.0, februari 2006); - Air (versie 1.0, januari 2012); - Human health (2002) - Noise and vibration (februari 2011)	The list of impact is standard and includes: - Air - Soil - Surface and underground water - Fauna and Flora - Human health - Noise and vibration

Thresholds: • **Does the guideline generally prescribe thresholds generic to each DGE project? Please give some examples.** **For impacts and risks with no thresholds, how are they defined?**		Thresholds that the developer of a DG project must respect concerning for example soil, water, underground water, Air emissions can be found in the regulation: - - VLAREM II + Appendixes, the Order of the Flemish Government from 1 June 1995 concerning general conditions concerning environmental hygiene - VLAREBO, The Order of the Flemish Government concerning the rules on soil remediation and soil protection of 14 December 2007 The thresholds are common to all sectors of activity, in that sense, it's not specific to Deep Geothermal.	No thresholds are defined by the guidelines. Thresholds are generally defined by other regulation (labor code, public health code, environmental code…)

Mitigation measures:
 	
• **Does the EIA guideline provide technological and non-technological prescriptions for the mitigations of the impacts?**
• **For impacts and risks with no thresholds, how are they defined?**
	The EIA report should include:
	
	• Article 8, §4: "Member States shall ensure that the features of the project and/or measures envisaged to avoid, prevent or reduce and, if possible, offset significant adverse effects on the environment are implemented by the developer, and shall determine the procedures regarding the monitoring of significant adverse effects on the environment"
	• Annex IV:
	  ○ Point 5. A description by the developer of the forecasting methods used to assess the effects on the environment.
	  ○ Point 7. A non-technical summary of the information provided such as e.g. the description of the projects, EI likely to be impacted.
	Annex IV, point 6. Description of the measures to prevent, reduce or offset
		The EIA office has guidelines on drafting a non-technological summary[35], and a handbook for general mitigation measures[36].
		
		For example, concerning:
		- light, heat and radiation, and noise and vibration, the guideline provides description of the mitigation measures that need to be described by the operator
		- Ground vibration, no thresholds are included, but for the Balmatt project, there was an obligation to measure, monitor the movement and draft a mitigation plan.
			The EIA guideline does not provide technological and non-technological prescriptions for the mitigations of the impacts.
			
			For impacts and risks with no thresholds, like induced seismicity, they are defined in the authorization for drilling or operation.

[35] https://omgeving.vlaanderen.be/sites/default/files/atoms/files/Niet%2520technische%2520samenvatting.pdf
[36] https://omgeving.vlaanderen.be/sites/default/files/atoms/files/Milderende%20maatregelen.pdf

Monitoring: • **Does the EIA guideline generally prescribe how to monitor the EIs (e.g. which tools, data format)? Please give some examples.** • **If not, how are monitoring procedures established?**	The EIA report should include: Article 8, §4: "The type of parameters to be monitored and the duration of the monitoring shall be proportionate to the nature, location and size of the project and the significance of its effects on the environment. Existing monitoring arrangements resulting from Union legislation other than this Directive and from national legislation may be used if appropriate, with a view to avoiding duplication of monitoring."	For example, The EIA of the Balmatt project includes monitoring and evaluation description for soil, ground water, noise and water, and the tools used to monitor.	In case that impact could not be mitigated, according to article R.122-5 of the environmental code, it is mandatory to describe how to monitor these impacts (example: seismicity, radioactivity…).
How is the EIA tailored to geological specificities of the project? Which are the criteria?		From the experience of Balmatt, the potential impact of deep drilling was a first case in the framework of the EIA for deep geothermal in Flanders.	EIA in the Paris basin do not include induced seismicity risk analysis thus this risk is not present contrary to the Upper Rhine Graben.
To what extent can the EIA process be characterized as flexible?		From the experience of Balmatt, the EIA procedure itself is well described, and there was good communication with the authorities.	

To what extent can the EIA process be characterized as transparent?	Point 18, 34 of the Directive (18) With a view to strengthening public access to information and transparency, timely environmental information with regard to the implementation of this Directive should also be accessible in electronic format. Member States should therefore establish at least a central portal or points of access, at the appropriate administrative level, that allow the public to access that information easily and effectively (34) With a view to ensuring transparency and accountability, the competent authority should be required to substantiate its decision to grant development consent in respect of a project, indicating that it has taken into consideration the results of the consultations carried out and the relevant information gathered.”	In Flanders, for the case of Balmatt: - The EIA was performed by an independent consulting firm (e.g. SGS Belgium NV for Balmatt) on the basis of the available information provided by the developer, and the guidelines provided by the Authorities. In that sense, an independent stakeholder allows to respect the checks and balance principles. - Also, the citizens are able to take part to the definition of the scope of the EIA prior to drafting the EIA report, through the notification by the municipalities within 30 days of the notification. The drafted guidelines are made public through: https://omgeving.vlaanderen.be/richtlijnenboeken-en-handleidingen	The EIA are performed by independent consulting firm based on the R.122-5 of the environmental code, public data and literature, onsite survey (noise, fauna and flora) and information provided by developers. Citizens have access to the content of the EIA during the public inquiry.

Table2

	Hungary	Italy
Regulation of the Environmental Impact Assessment		
What is the type of regulation that defines EIA in your context? (e.g. a national law, regional, sectorial conditions) **Please indicate if there are more than one regulation.**	Governmental decree of 314/2005 (XII.25) on Environmental Impact Assessment	The national decree *DLGS 152/06* (Legislative Decree of 3 April 3, 2006, n. 152) and following modifications states the competence in leading the EIA procedure. According to the type of the project the competence can be assigned to 1) Ministry of Environment jointly with Ministry of Cultural heritage for “pilot plant”, foreseeing total reinjection of fluids 2) Regions. Each Region defined its own Regional regulation establishing procedures and technical content of the Environmental Impact Study (EIS) Two types of environmental procedures are provided for geothermal projects: Environmental Impact Assessment Screening and Environmental Impact Assessment (EIA).

When is the EIA mandatory in your country for Deep Geothermal projects?	Annex 1 and 3 list activities for which an EIA procedure must be commenced. In deep geothermal context these are the following: • geothermal plants (power or heat) if (a) capacity is above 20 MW, (b) it is within the protection zone of mineral-, medicinal- or drinking water resource, (c) it is within a Nature 2000 area. • thermal water abstraction exceeds 500 m^3/day from thermal karstwater, or 2000 m^3/day from thermal groundwater (porous) resource • deep drillings (depth is not specified) if it is within the protection zone of mineral-, medicinal- or drinking water resource, and/or Nature 2000 area • reinjection (without limits on the amount) into thermal groundwater bodies (geothermal aquifers)	The EIA procedure is mandatory for all the requests of Concession for the exploitation of deep (>400 m) resources and exploration permits of "Pilot Plants" *(DLGS 152/06 Annex 3 to second part letter v)* The EIA screening is required for the request of exploration permits including deep drillings and exploratory activities (geophysical surveys, provided that the activities are outside protected areas) *(DLGS 152/06 Annex 4 to second part point 2a).* In practice, nevertheless, complete EIA procedure has been requested for all deep drilling also in the exploratory phase.
Under which conditions can competent authorities provide an exemption of the EIA for a Deep geothermal project?	Environmental permitting is a 2-step procedure. First a so-called preliminary study has to be done, which content is defined in Annex 4. Then, the environmental authority assesses the preliminary study (involving respective co-authorities) based on the conditions defined in Annex 5. If the environmental impacts are considered as not major, then activities may start without an EIA (= exemption), but the authority defines the necessary permissions. If the environmental impacts are considered as major, then the authority prescribes the preparation of a full EIA, which content is defined in Annex 6), which is the prerequisite for an environmental permit	Exemption from EIA procedures may be allowed for light exploration activities (geologic survey, some magneto telluric) not performed in protected areas.

What are the main elements the EIA must include for a DG project?	Very similar for the preliminary study and the full EIA, which are the following: • Aim and full description of the planned activity (location, time, required infrastructure including transportation, planned technology. waste management, energy and water supply, spatial planning issues • impacts of activities above on landscape, biodiversity, built environment, cultural heritage, surface and groundwaters, soil, air, geological environment, climate, etc. • potential transboundary effects • full analysis of potential interactions	Typical Index of EIA Report *according to Annex 7 of DLGS 152/06* comprises: *Non-technical summary* *Planning and legislative Terms of Reference (including definition of Protected areas)* *Project Description* *Existing (initial state)* *Environmental Situation* *Environmental Impact Prediction* *Applied mitigation measures and monitoring plan* *Risk analysis* *Compensation measure*

What are the main elements the screening procedure must include for a DG project?	As the majority of environmental criteria are related to groundwaters (abstraction limits, reinjection, protection zones of mineral-, medicinal- or drinking water resource), these are decisive factors and the role of the water authorities (Regional Directorates for Disaster Management) as responsible co- authority in issuing an environmental permit is more important, than that of the environmental authority itself.	1. Objectives of the exploratory program. 2. Description of exploratory techniques *2.1 Description of geophysical detection systems concerning:* Typology of the elastic wave's sources Electrical survey details and location of electrodes Type of the potential bursting wells Vehicles to be used Restoration techniques of the potential bursting wells Restoration techniques of the transport vehicles passage ways Execution time Regulatory framework and reference standards *2.2 Description of the drilling operations, with particular reference to:* Location preparation techniques Drilling techniques and circulation of the drilling mud Piping techniques and water tables protection techniques *2.3 Environmental risk prevention techniques* *2.4 Environmental impact mitigation methods and monitoring:* Estimate of solid waste, air emissions and noise and vibration production Waste water treatment methodologies (including *drilling debris)* 2.5 *Potential closure of the well or development, with plan for territory restoration* 3 *Existing Environmental Situation* 3.1 *Regional Landscape Plan* 3.2 *Definition of the operation area*

		3.3 *Definition of the territory and description of the environmental systems involved in the program, on thematic maps*; Land use, restrictions, protected natural areas, Hydrological environment: characterisation of surface water bodies Land and soil: geomorphological seismic and hydrogeological characterisation Vegetation, flora, fauna and ecosystems Landscape

The content of the EIA: defining thresholds and mitigation measures

Is there a dedicated guideline for EIA in your country? Does it include specificities on DG projects?	Annex 4 and Annex 6 of the Governmental decree of 314/2005 (XII.25) on Environmental Impact Assessment provide full details on the contents. No other guidelines exist. There are no specifics for DG projects. However, there are some good examples, when environmental authorities are open for consultation with the project developer when preparing application for an environmental permit.	Guidelines of Ministry of Economic Development and Ministry of Environment provide general recommendation to avoid environmental impacts and risks, including seismic. They are not specific for EIA Each Region provides their own EIs guidelines. Only Tuscany Region provides regulations and guide lines for Geothermal Projects.
Scope: **Is there a predefined list of impacts for DGE in the EIA guideline?** • **If so which environmental impacts and risks must be reported?** • **If not, how is it decided which impacts and risks are in scope?**	No (see above)	All impacts and risks foreseen in general EIA are required for DGE, and applicants simply declare what does not apply

Thresholds: • **Does the guideline generally prescribe thresholds generic to each DGE project? Please give some examples.** • **For impacts and risks with no thresholds, how are they defined?**	No specific thresholds defined in the EIA itself. Thresholds for each environmental element (e.g. groundwater, air, etc) are defined in the respective legislation and it is individually assessed by the relevant authority how significant these impacts are.	Guidelines in Tuscany refer to the thresholds defined by regional regulation (emission limits for H2S, SO2 and Hg from geothermal plants, maximum allowable H2S concentration during production tests) and national regulation (noise; air and surface and underground water quality, emissions).
Mitigation measures: • **Does the EIA guideline provide technological and non-technological prescriptions for the mitigations of the impacts?** • **For impacts and risks with no thresholds, how are they defined?**	N.a.	All mitigation measures must be described in EIS, but there is no a priori prescription. Impacts are simulated by mathematical modeling and the predicted variation are compared with threshold limits given by the national or regional limits. For impacts and risks with no thresholds, the latter are defined in the authorization for drilling or operation, case by case.
Monitoring: • **Does the EIA guideline generally prescribe how to monitor the EIs (e.g. which tools, data format)? Please give some examples.** • **If not, how are monitoring procedures established?**	The EIA does not prescribe details of monitoring. Monitoring requirements (if any) to assess the environmental impact of each element (e.g. groundwater, air, etc) are defined in the respective legislation.	The monitoring plan is not detailed in the guidelines, but general concepts are defined in the MISE-MATTM guidelines. Monitoring is proposed by applicants case by case and checked by authority. Typically, the monitoring plan include: Piezometric wells to monitor aquifer level and chemical variation of potential potable aquifers Microseismic activities by means of a network of seismic sensors installed according to national guidelines Noise level (LEQ day and night) at the nearest receptor before and after the operation o well or geothermal plant.

How is the EIA tailored to geological specificities of the project? Which are the criteria?	Not tailored	A geological report containing the main characteristics of the geothermal reservoir to be investigated is submitted to the Competent authority to have the approval of the exploration permit working plan; all features related to the geology (type of investigation, foreseen impacts and risks and mitigation measures) are included and evaluated by the authority.
To what extent can the EIA process be characterized as flexible?	Not flexible	Presently in Italy no flexibility is accepted: EIA must be based on a "definitive" design. Any change to the project must be approved by the competent authority.
To what extent can the EIA process be characterized as transparent?	The full process is transparent. The application, the preliminary study, the assessment and the final EIA are all publicly available at the environmental authority's website + the authority must send these documents to the notary of the related municipality(ies). Within 5 days the notary must make publicly available all received documents within the municipality (the exact form is not defined, can be local newspaper, local media, etc.), which have to be available at least for 30 days, and/or can organize public hearings. During the permitting procedure the local public / municipality can submit its questions and concerns to the environmental authority (see also public participation template).	The EIA procedure is completely transparent: all the documents prepared by the developers are public and easily downloaded from the Competent Authority internet site. Public may give his opinion by letters and communications that are public and published in the internet site of the competent authority.

Local benefits data collection

	France	Iceland	Italy		
National or regional framework		National	National	Regional	Local
Authority		Orkusjóður (National energy fund) and lump sum subsidies for municipalities	Ministry for the Economic Development, Regional government	Tuscany Region	Tuscany Region, Geothermal Municipalities, their associations (i.e. Mountain Communities) and Provinces of Siena, Grosseto and Pisa CoSviG for the implementation of projects reported in multiyear plans for the local development
Regulation	Mining code, 4 Décret n°78-498 du 28 mars 1978 relatif aux titres de recherches et d'exploitation de géothermie Modifié par Décret n°2019-1518 du 30 décembre 2019	Act no. 76/2020 Act no. 78/2002	Legislative decree 22/2010	Regional Law 07/2019	Memorandum of Understanding between the operator[37] and the Region and a list of voluntary agreements with local authorities. Regional decrees: DGR 607/08 and DGR 291/09
Mandatory	Yes (except for the communal and departmental fee)	No	Yes	Yes	No

[37] The operator that signed these agreements is Enel, the sole operator with operative geothermal power plants in Italy so far.

Prescription	The operator must demonstrate its technical and financial ability to operate (art 4 Décret n°78-498 du 28 mars 1978 relatif aux titres de recherches et d'exploitation de géothermie Modifié par Décret n°2019-1518 du 30 décembre 2019) Taxes exists for - geothermal exploration permit (refer to Geoenvi D4.1 deliverable p.21 to see the French licensing and authorization process), annual tax proportional to the surface of the requested permit collected for the benefit of the local authority (Département) Code général des impôts, artic. 1591 - there is a land fee from the concession holder to the owner of the land (mining code L132-15) - a communal and departmental fee exists for the benefit of the municipality and department but it is not perceived	Since 1953 the national energy fund has supported geothermal development in areas where geothermal heating is not yet accessible. It contributed to the very rapid growth in geothermal heating between 1970 and 1985. Municipalities can apply for funding, if the development is successful the funding is a loan with favourable interest, if it is not successful the funding is a grant and does not have to be repaid. In recent years this has mostly been replaced by the possibility of municipalities and other entities using subsidized electric heating to access a lump sum of 16 years equivalent of subsidies to finance geothermal development. The energy fund also	Taxes (see GEOENVI D4.1 deliverable for details) for exploration leases and concessions, land use.	Authorization for new plants is subject to planning environmental and social improvement. Positive social, employment and economic effects in a circular economy perspective are required, as related to both the plant operation (environmental mitigation measures), as resulting from direct heat uses (at least 50% of waste heat) and from the use of CO_2 (at least 10% of gas emission)	The amount allocated to the Region by national laws on geothermal permits and fees constitutes a "Geothermal Fund" (Fondo Geotermico), corresponding to about 10 M€ per year(from 2007 to 2024), managed by local authorities for the planning, coordinated and implemented by COSVIG. Further funds are provided by the operator: - Up to 130 M€ in 10 years up to 2024 to local municipalities for new plants - about 250 M€ invested by the operator in priority for R&D&I projects

	A revision of the mining Code is underway. The land fee could be removed because its revenue is very low. Conversely, the departmental and communal fee could be revalued in order to provide better compensation to the local territories	funds various low carbon research projects, including geothermal. The emphasis is decided each year.			
Beneficiaries	Owner of the land, local authorities	Municipalities, public and private entities	Regions and municipalities with geothermal leases	Geothermal municipalities in Tuscany	Tuscany Region, municipalities (15), provinces (3), Mountain Communities (5)
Period of application		Every year	From 2010 onwards	From 2019 onwards	2009 (year of enforcement) - 2024 (end of current concessions)
Public data	The documentation on the financial ability of the operator is part of the requested documents for obtaining of the mining title or work permit. Some information can be part of the documentation of the public inquiry	Yes	Not required by the law	Not required by the law	Not required. Activities funded by geothermal funds are advertised and listed on the homepage of the CoSviG website
Organization collecting public data	State (central or deconcentrated)	Orkusjóður	-	-	CoSviG
Types of data available to the public		Description of projects that are funded, and amount of grant	-	-	Brief description, date and duration, budget (total budget and contribution from geothermal funds)

Produced benefits	- direct and spin-off jobs - industrial tourism (example the energy city project in Merkwiller-Pechelbronn) - territorial attractiveness - low cost heat for household the Paris basin, for industrials in Alsace - research and development perspectives; - educational potential, - decrease in CO2 emissions and contribution to the climate change policies	Further development of geothermal heating. Research and innovation in the geothermal sector. Funding for projects in areas with less developed geothermal.	Taxes should be used as investments in energy savings and recovery, to increase geothermal applications, to improve local environmental protection, as well as for the socio-economic development.	Improved environmental control and mandatory direct use of heat	- Observatory on geothermal energy - Communication activity - Air quality monitoring - Support to energy efficiency projects - Infrastructures for tourism (e.g. museums and thematic park), market and trade, ICT, road and building maintenance and renovation - Socio economic development (territorial marketing and support to local business) - RES and energy efficiency promotion - establishment of a training agency on energy related topics

Other benefits	-	Economic benefits for local communities due to lower energy bill and innovative companies using geothermal in industry. Increased tourist attractions in the form of spas, museums and other things, resulting in more jobs and taxes for local municipalities.	-	-	Economic benefits for local communities due to lower cost for heating in towns with geothermal DH. Increased tourist attractions in the form of parks, trails, museums and industrial tourism, resulting in more jobs and taxes for local municipalities.

Information sharing data collection

	Iceland	France	Hungary	Italy
Regulation on the access to information				
Regulation(s)	140/2012 upplýsingalög/information act	Constitutionnal law n°2005-205 regarding the environnemental Charter, Grenelle II law n°2010-788 , Ordonnance 3 aout 2016, decret n°2017-626, décret n°78-498 du 28 mars 1978 modifié par le décret n° 2019-1518 du 30 décembre 2019 – the mining code refers to the environment code (art L123.1.A except for the Exclusive Research permit PER, artic. L123.19.1 to 7). Please refer to Geoenvi D4.1 deliverable p.21 to see the French licensing and authorization process	CXII Act of 2011 on Information	National Decree 195/ 2005, implementing 2003/4/CE
Prescription	This act guarantees the publics access to information on environmental matters that is collected by public authorities	Public must be informed and allowed to express its opinion. It is done through "public inquiry" except for PER, it is an "online consultation" (please refer to Geoenvi D4.1 deliverable p.21 to see the French licensing and authorization process).	Regulates the access to data of public interest, however which data are of public interest is not specified at general level	This act guarantees the publics access to information on environmental matters that is collected by public authorities
Restrictions to public access to data	Yes, detailed in the 57/1998 act on resources. In practice companies can ask for confidentiality regarding exploitation	The exploiting data are confidential		Environmental data may be accessed after request; exploitation data are confidential for 15 years after the end of the concession

	while exploration data is confidential for the duration of a licence			
National or regional framework	National	National framework but adapted regionally to each site	National	National
Authority	Prime minister's office, request for information should be sent to relevant authority	Deconcentrated authority or ministry		National (Ministries, Geological Survey) and regional authorities (ARPA, regional agencies for the environmental protection)
Mandatory	Yes	yes	Yes	Yes
Right to appeal	Yes, to an independent Appellate Committee on Information Matters	All the provisions of the Aarhus convention are not directly appealable. But appeal is always possible;		-

Data sharing practices and tools in the context of deep geothermal development

Public data availability	All data collected on geothermal utilization by national energy authority is published on the web. In addition, all exploration reports funded by public funds has been made available for anyone to use.	For the geothermal operations targeting the Dogger formation in the Paris basin, production and test data are centralised in a database edited by the BRGM (SYBASE). This database is addressed to operators only and is accessible for them through restrictive access. End of work reports (DOE) transmitted to the authorities at the end of drilling period and after work overs are public. Some geological information is accessible on the website infoterre,	geology-geophysics related data (maps, boreholes, etc.) preparatory data for geothermal concessions exploration reports hydrogeological data energy production data water chemistry data	Some (see below) data collected by national and regional authorities are published on the web. Production data are also collected and organised by the authorities and geothermal association.

		Minergie, Géothermie perspective... All data, like seismic survey, geological logging (gamma ray, sonic, porosity…) become public domain 10 years after the acquisition		
Organization collecting public data	National Energy Authority (geothermal utilization data), Local health authority, Environmental agency of Iceland, Municipalities (environmental data).	State authorities (central or deconcentrated) collect the data	Mining and Geological Survey of Hungary: (geology-geophysics, National well cadaster, National Hydrogeological Archive), concession Hungarian Energy and Public Utility Authority: energy statistics Central Statistical Office: general General Directorate for Water Management and regional water directorates: all water management related data National Public Health and Medical Officer Service: mineral and medicinal waters	Ministry of Economic Development (permit areas, liberalized well data, production data) GSE (production data, incentives), ARERA (production data) ARPA in Tuscany (environmental data), ARS in Tuscany (Health data), geothermal association, DH association (production and technical details) CNR (geothermal database, potential, maps of resources, regulation)
Types of data available to the public on geothermal:	Utilization data, consumption data, financial data, drawdown data, emissions (H2S, CO2, CH4), published annually on the web. Status of ground water, drilling reports, geological maps	The End of work report (DOE) includes all technical aspects. The citizen has to ask for it to the public authorities	The national geothermal information system (called OGRe) developed by the Mining and Geological Survey of Hungary will be launched at the end of October 2020 and will be available via:	Permit areas Production data Liberalised well data (after embargo period) Some environmental data in the Tuscany Region

	and figures, mostly localised problems monitored by health authority available upon request. https://nea.is/the-national-energy-authority/energy-data/data-repository/ https://ust.is/loft/loftgaedi/ Reports for specified monitoring of individual power plants		https://map.mbfsz.gov.hu/ This web-map based interactive portal will be publicly available with the following data for the entire territory of the country: • top and bottom bounding surfaces of the main geological formations • set of isotherm maps (depth of the 30, 50, 75, 100, 125 C isotherms) with the Neogene basin fill sediments • calculated temperature for the pre-cenozoic basement • map series showing the top and bottom bounding surfaces of the potential geothermal reservoirs • all data (basic data + utilization, outflow temperature, screened intervals and their geology, piezometric levels, water chemistry, gas content) of 1695 thremal water wells (outflow temp above 30 C)	

			• basic data of hydrocarbon wells (8996) and boreholes deeper than 500 m (12539) • data about geothermal concessions (with downloadable reports) • maps of geophysical coverage (2 and 3 D seismics, well-logs, magnetotelluric s, gravity, magnetic anomaly and telluric conductivity maps) reports	
Which tools and approaches are used to make public data available and accessible to inform the public debate?	Interactive websites, published reports online, map portals, public information meeting. Requests for information that has not been made public yet.	The public inquiry is the key moment of communication with the public. A non-technical note comes with the documentation. There is flexibility in the way the public inquiry is organized (public debate or not, prior concertation or not…) so it can vary a lot from an operation to another. Other available information to the public (DOE) is technical information with no mediation. The public has to ask for it.	Interactive websites, webmap services, public reports	websites, published reports online, map (webGIS) portals

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