Interreg CENTRAL EUROPE

Co-funded by the European Union

TRANSGEO

Report on regional comparison of policy frameworks for well repurposing

TRANSGEO Deliverable 3.1.1

Version 3

06 2024

D.3.1.1 REPORT ON REGIONAL COMPARISON OF POLICY FRAMEWORKS FOR WELL REPURPOSING

Corresponding authors			
Monika Hölzel Doris Rupprecht	GeoSphere Austria	monika.hoelzel@geosphere.at doris.rupprecht@geosphere.at	Austria
Contributors			
Matej Prkič	Local Energy Agency Pomurje (LEAP)	matej@lea-pomurje.si	Slovenia
Tomislav Kurevija Marija Macenić	University of Zagreb - Faculty of Mining, Geology and Petroleum Engineering (UNIZG - RGNF)	tomislav.kurevija@rgn.unizg.hr marija.macenic@rgn.unizg.hr	Croatia
Danijela Vrtarić Ema Novak	Medjimurje Energy Agency Ltd. (MENEA)	danijela.vrtaric@menea.hr ema.novak@menea.hr	Croatia
Katrin Sieron Sebastian Weinert Thomas Höding	Geological Survey, and Mining Authority (LBGR)	Katrin.Sieron@lbgr.brandenburg.de	Germany
György Márton Klára Bődi Gábor Magyar Judit Schäffer	CROST Nonprofit Ltd. Co. (CROST) and Mining Property Utilization Nonprofit Public Ltd. (BVH)	schaffer@crost.hu bodi.klara@bvh.hu	Hungary
Sabine Appelt Werner Donke	Greenwell Energy GmbH (Greenwell)	sabine.appelt@greenwell.energy werner.donke@greenwell.energy	European Union

Table of Contents

Executive Summary

The overall objective of the TRANSGEO project (https://www.interreg-central.eu/projects/transgeo/) is to investigate the potential to transform abandoned hydrocarbon wells into new sources of green geothermal energy. The main outputs of the project TRANSGEO include a transnational well repurpose potential assessment, site-specific feasibility studies, validated well repurpose methodologies, a web-based tool for assessment of well repurpose potential, and a transnational strategy and action plan. The uptake of these outputs will be ensured by a Cooperation Agreement for long-term support of well repurposing in Central Europe. Transnational cooperation is indispensable because of the following reasons: (i) technological, legislative, economic and social challenges related to structural change and heat transition are very similar in the considered regions; and (ii) competences and expertise of project partners operating in science, industry, regional development, and regulation in different countries are essential for the development of joint novel solutions for well repurposing.

This report provides a comprehensive overview of the policy framework status of well reuse projects and their integration into energy planning in the TRANSGEO partner countries: Austria, Hungary, Croatia, Germany, and Slovenia. The report reflects the authors´ view and the potential possibility of reuse of abandoned wells, which can vary depending on the actual situation and specifics of the individual location. The project is funded by the Interreg Central Europe program and the European Regional Development Fund.

Status evaluation of reuse projects in the TRANSGEO partner countries shows that all five TRANSGEO partner countries have realised either Deep Borehole Heat Exchanger (DBHE) projects, Hydrothermal Energy (HE) projects, or Enhanced Geothermal Systems (EGS) within the last 15 years. Some of them were planned as research projects and are no longer in use and some are still producing green energy.

In Hungary and Germany, well reuse is included in political agendas. Hungary's state-owned Mining Property Utilization Nonprofit Public Ltd. oversees reusing state-owned hydrocarbon wells to reduce dependence on energy imports. Germany includes well reuse indirectly as part of the general geothermal energy concept in national, regional, and local energy plans. In Croatia, the focus is on hydrothermal energy exploration, with well reuse being a minor topic primarily discussed with local representatives or interested companies. In Austria and Slovenia, there is no significant political interest, and company interest is negligible. While the European Union Renewable Energy Directive (RED) and the Strategic Energy Technology (SET) Plan promote geothermal energy, they do not yet focus on reusing existing wells.

Bringing together current well owners, consumers, investors, and interested groups is essential. Some owners are interested in reuse, while specialised companies may take over operations to establish geothermal facilities.

The comparative legal and administrative procedures regarding wells and well data show that drilling regulations are defined by the states' mining or water acts in all partner countries. Licences are based on resources, requiring permits for specific uses such as hydrocarbons or heat. In Germany, Slovenia, and Croatia, legal processes for (geothermal) drilling and well use are governed by these regulations. Hungary has a unified Mining Act integrating well reuse explicitly, while Austria requires licences for hydrocarbon exploration and production but lacks a licence system for geothermal water usage.

Well status, technical equipment, and reservoir properties must be reported in all countries, but existing records can be incomplete. Data availability varies, with some countries providing open access and others restrict access to certain parts of the data without the explicit consent of the data owner. Data ownership typically remains with the initial operator or investor, but some states have a copy of these data or even have the initial ownership of data.

Investigation of the financial framework and funding opportunities show that national funding for well reuse is explicitly included into a funding programme in Austria, while Slovenia and Croatia rely on indirect financing through national subsidies, tax relief, and grants. Germany has no specific national funding or

federal funding for reuse, but there are programs for geothermal research and development, where reuse projects and research can be funded. Hungary anticipates national funding, mainly by the new Swiss-Hungarian Cooperation funding scheme. All 5 TRANSGEO partner countries can apply for EU funding opportunities that include Horizon Europe, the European Structural and Investment Fund (ESIF), and InnovFin Energy Demonstration Projects, among others.

Overall, there are no political, legal, or financial barriers that would prevent successful reuse of existing wells for geothermal purposes, which has also been proven by first reuse projects in all five TRANSGEO partner countries. However, the number of projects, the political integration, the legal frameworks, and the financial support vary significantly between countries. Therefore, continued cooperation and development of comprehensive strategies are essential to improve the conditions for reuse of hydrocarbon wells for geothermal energy production and storage in Europe.

1. Introduction

The TRANSGEO partner countries jointly analyse and compare the legal, administrative, and financial frameworks for well repurposing in the partner countries Germany, Austria, Hungary, Croatia, and Slovenia as well as for the European Union (EU, as far as applicable) in the "Report on Regional Comparison of Policy Frameworks for Well Repurposing."

This report contributes to the definition of the Criteria Catalogue in TRANSGEO project Activity 1.3 which, together with Deliverables D 1.2.1, D 1.2.2 and D 1.2.3 (socio-economic analyses of well reuse for industry, agriculture, and municipalities) forms the basis for developing the transnational well repurposing strategy and action plan in project Activities 3.2 and 3.3. Understanding the socio-economic aspects of the regions under investigation, as well as the policy framework and funding options, is crucial for developing strategies to promote well reuse.

The analysis focuses on highlighting the differences and similarities in policy frameworks at the national level. It points out the main policy-related bottlenecks and good practices that can be applied at the transnational level.

In this report, we consider the reuse of existing hydrocarbon wells for deep geothermal utilisation, including examination of the public perception and management of deep geothermal energy. An important question concerns whether the reuse of wells is already being taken into account or whether this possibility needs to be promoted more strongly. The current state of regulations concerning deep drilling and geothermal energy is examined. It is important for investors to be familiar with the submission procedures for geothermal applications or, if possible, also for the reuse of oil and gas infrastructure. This includes awareness of how projects can be developed and where information is available and in what form. Financial incentives for project implementation are additional factors in increasing the use of geothermal energy production.

The information provided for the 5 TRANSGEO partner countries in this report represents the situation at the time of writing (spring 2024). The field of renewable energy generation is currently undergoing major changes, thus it is likely that some information in this report will be out of date at a later time. The aim of promoting the energy transition should be to simplify administrative, legislative, and financial regulations for investors and users. The regulations should then be standardised at the EU level.

2. Basic data of partner countries

The size and population of the five TRANSGEO partner countries is quite heterogeneous (Figure 1). Partners range from small countries like Slovenia with 20.273 km² and 2.1 million inhabitants to large countries like Germany with 357.600 km² and a population of 84.4 million people. Hungary and Austria have a comparable size and population and Croatia lies in between Slovenia and Hungary/Austria. The population density is relatively similar in Hungary, Slovenia, and Austria (103-108 inhabitants/km²), while it is smaller in Croatia (69 inhabitants/km²) and larger in Germany (236 inhabitants/km²). A larger population means there is a larger heating market and a higher population density makes heat transfer via district heating systems more economic.

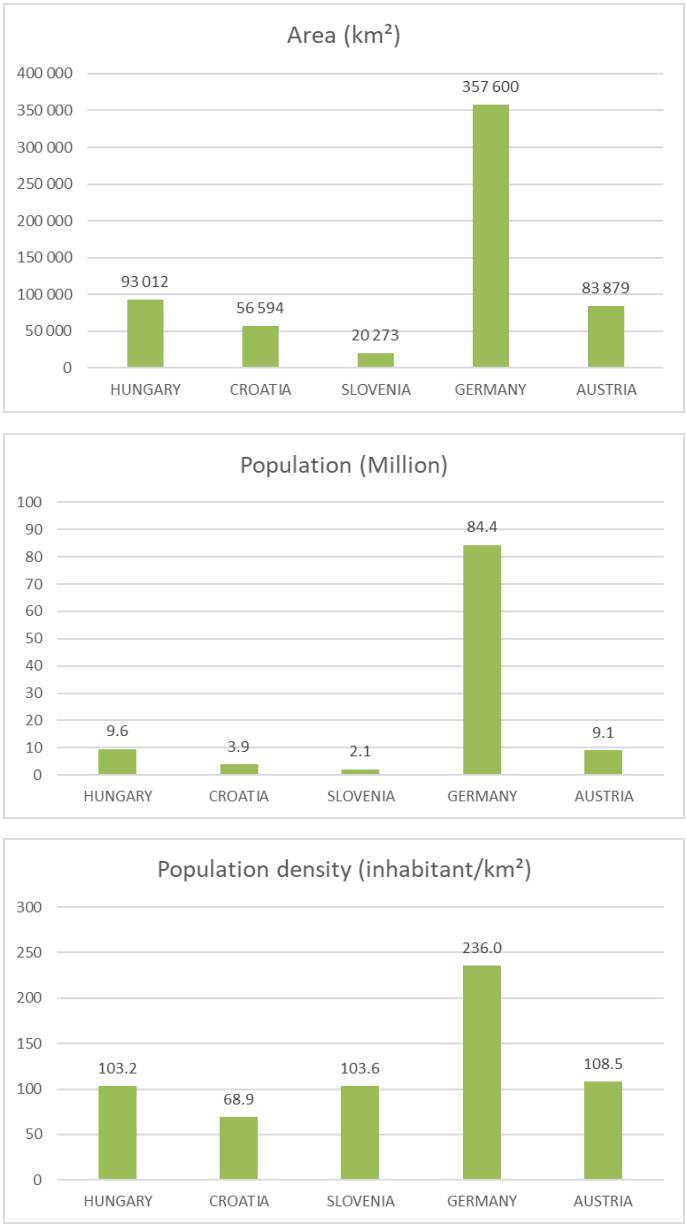


Figure 1: Area (top), total population (middle), and population density (bottom) of the 5 TRANSGEO partner countries (Source: Eurostat).

3. Methodology

This deliverable presents for the TRANSGEO partner countries Germany, Austria, Slovenia, Croatia, and Hungary a summary of the national legal requirements, policies, and regulations for deep wells, from drilling and production to shut-in or abandonment, with information on the necessary technical documentation.

It is important to note that these requirements can vary significantly between countries and regions. To provide an overview of the most important topics in the partner countries, a detailed questionnaire (Appendices 1-5) was developed. To identify the most important topics and associated questions, we based our questionnaire development process on the general workflow for identifying and reusing existing boreholes (Figure 2).

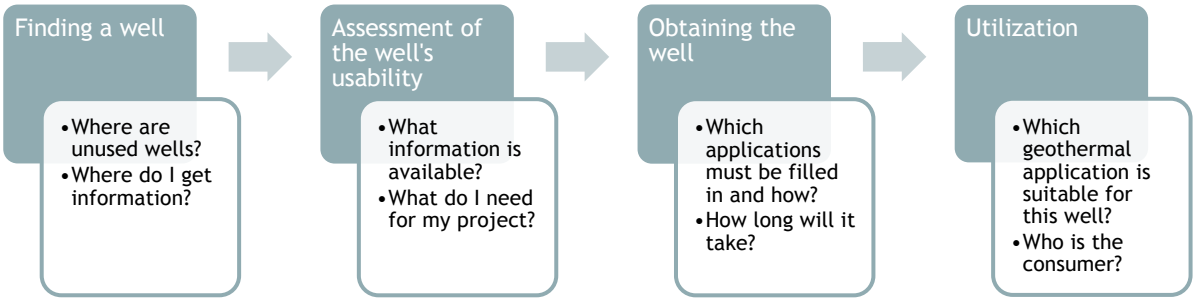


Figure 2: Overview of the most important steps and associated questions for the reuse of a well.

Upon closer examination of the questions, it becomes evident that describing and comparing emerging topics across countries requires familiarity with both the legal framework and actual administrative practices. This applies not only to the reuse of wells, but also to their installation and handling, as well as their original purpose.

For the questionnaire, four subchapters were defined.

(1) Data, well ownership, and well condition

- Finding a well → Information about location and ownership of wells; Status of the well (active, shut-in, temporary or permanently abandoned) + regulations concerning the abandonment of wells
- Suitability → Information on well, geology, potential for energy use, and well ownership
- Well condition → year of drilling, years of production, well integrity

(2) Data and utilisation

- Picking a well → Information about the potential for reuse of an existing well, considering geology, hydrogeology, availability of well testing data, and other factors
- Possibilities and challenges for change in well/licence ownership

(3) Legal framework and licensing/administrative procedures

- Legal basis for the utilisation of geothermal energy
- Legal basis for the reuse of wells
- Administrative procedures for reuse of wells

(4) Finances and funding

- Support on the national or EU level
- Traditional and innovative financing options
- Other financial support

The questionnaire comprises a total of 58 questions. After receiving the responses, a workshop was held to discuss and summarise the results in a table, which shows a comparison of the major results for each country (Appendix 6).

Questions 1 – 32 cover legal and administrative matters, with some overlapping topics to provide a better overview of these complex topics. Questions 33 - 58 discuss the financial framework and funding opportunities for reusing wells in the TRANSGEO partner countries.

Participants were asked to consider the five different geothermal technologies, including Deep Borehole Heat Exchangers (DBHE), Borehole Temperature Energy Storage (BTES), Aquifer Temperature Energy Storage (ATES), Hydrothermal Energy (HE), and Enhanced Geothermal Systems (EGS), and any differences in their application in well reuse. The questionnaire also included a section on the perception of the 5 geothermal technologies in terms of their implementation and consideration in energy planning.

The questionnaires of all TRANSGEO partner countries can be found in Appendices 1-5. The subsequent chapters present the main results and provide background information. The headers containing the letter “Q” followed by a number refer to the question numbers in the questionnaires.

4. Status of existing well-reuse installations and integration into energy planning in the TRANSGEO partner countries

4.1. Reuse projects in the partner countries (Q1)

In **Austria,** two projects have been executed with Deep Borehole Heat Exchanger (DBHE) technology. One was located in the Weinviertel region, Vienna Basin from 2009 until 2012 (Bräuer, 2011) and the other is in the Molasse Basin (Doppelreiter, 2012; Doppelreiter, 2014). Another DBHE project in the Vienna Basin using a dry hydrocarbon well was stopped because of the lack of the end users for the heat. Another reuse project is an injector for Hydrothermal Energy (HE). A dry hydrocarbon wellbore is used as injector for a hydrothermal doublet in the Styrian Basin. An Aquifer Thermal Energy Storage (ATES) case study in the Vienna Basin highlights that reusing wells is preferred over drilling new wells for economic reasons (ATES Vienna Project homepage, 2021).

In **Hungary** eleven reuse projects were executed for hydrocarbon wells that were originally non-productive or that are no longer productive. They are: DK-I, GBF-4, Sáv-02, Nu-18, Kál-1, Kiha-D-7, Nu-02, GB-05, Tiszalapár-1, Tiszaalpár-I, and Gátér-M-1, which are situated in the North-East and South-East of Hungary and in the Hungarian Great Plain in 8 different cities. The wells are state-owned and have been used for district heating, agricultural purposes, balneological, electricity, and power generation since 2016. The process is continuing as several projects located on the Great Plain and South-West Hungary are planned for use in agriculture for heating buildings, greenhouses, and foil tents. There are plans to use certain wells for electricity production for industry.

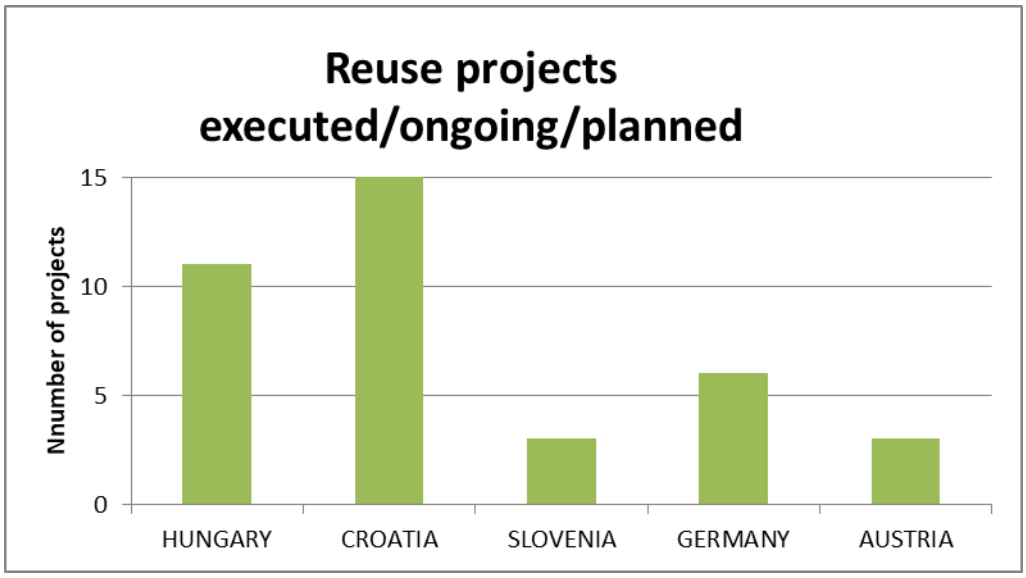


Figure 3: Numbers of executed and planned reuse projects including all 5 geothermal technologies investigated within TRANSGEO.

Croatia developed many wells within old hydrocarbon fields, mainly for hydrogeothermal reuse. There are three fields, Velika Ciglena, Bizovac, and Ivanić in operation for community or private heating purposes. Five similar projects concerning geothermal brine production and repurposing exploration or exploitation wells are planned. They are Lunjkovec-Kutnjak, Babina Greda, Ernestinovo, Merhatovec, and Slatina-2. For further detail, see Appendix 4 (Tuschl et al., 2022).

In **Germany**, at least five reuse projects have been executed: Two are EGS projects, Groß Schönebeck and Horstberg, both located in the North German Basin and used for research purposes, two are DBHE projects, both in Landau/Pfalz, and one is an HE project. Future plans include DBHE projects in Hessen (personal comm., company Endteufe).

In **Slovenia**, there are operational reuse projects covering HE production, Terme Lendava and Moravske Toplice with the well Mt-1, and one DBHE project, Benedikt v Slovenskih Goricah. A recent project aimed to inject geothermal water after use but unfortunately failed.

4.2. Political topic - Energy planning including reuse (Q4)

This section provides a summary of whether national, regional, or local energy plans mention well reuse, and whether companies or other entities show interest in well reuse. The partners were asked to estimate the importance of the topic within political planning.

In **Hungary** and **Germany**, the topic of reuse is listed on the political agenda. For instance, in Hungary, the state-owned Mining Property Utilization Nonprofit Public Ltd. is responsible for reusing hydrocarbon wells that were originally non-productive or are no longer productive. The Hungarian Government aims to reduce the country's dependence on energy imports by replacing up to 1-1.5 billion cubic meters of natural gas per year until the end of the decade with geothermal energy, incorporating well reuse in their planning. In Germany, this topic is included in national, regional, and local energy plans (e.g., Federal Ministry for Economic Affairs and Climate Action – Press Release, 2022).

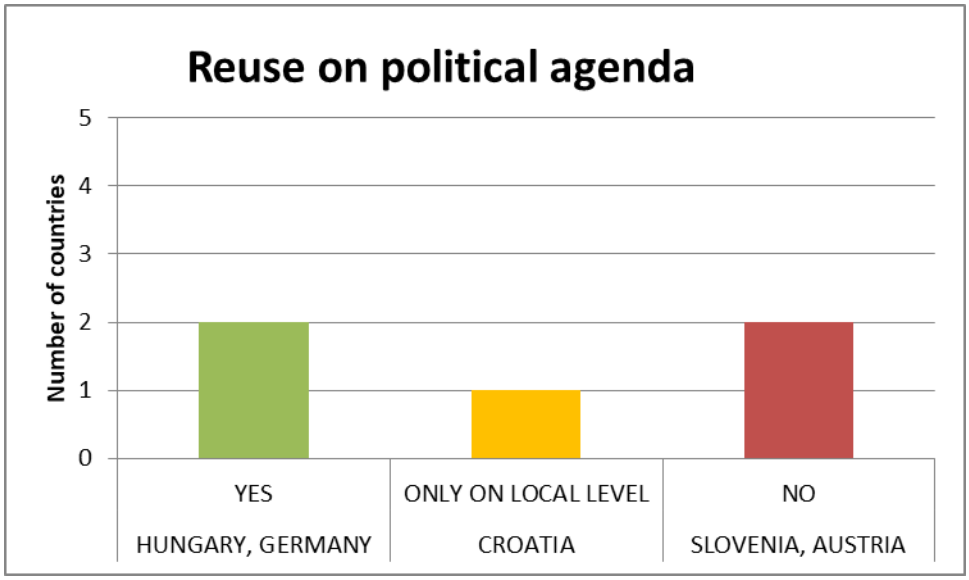


Figure 4: Number of countries for which the topic of well reuse is on the political agenda (green), only on the political agenda at the local level (yellow), and not on the political agenda (red).

In **Croatia** the focus lies on hydrothermal energy exploration. Reuse is a minor topic, mostly on the local level with direct conversations with regional, or more often local, representatives or with interested companies.

For **Austria** and **Slovenia**, the political interest in reuse is low. Although Austria is naming reuse in one geothermal funding program (Kommunalkredit Personal Consulting KPC, 2024), the interest of companies is

negligible, which is based on the fact that well ownership transger is not regulated or possible for single wells.

While the Renewable Energy Directive (RED) and the Strategic Energy Technology (SET) Plan demonstrate the **European Union**'s commitment to promoting the development and utilization of geothermal energy as part of its efforts to transition to a more sustainable and low-carbon energy system, there is not focus yet on the reuse of existing wells.

4.3. Reuse interest groups (Q4/Q6)

To encourage and facilitate well reuse, it would be beneficial to bring together well owners with energy consumers and other interested groups. Recent well owners may be interested in reusing existing infrastructure. In addition, companies specialising in well reuse may overtake the operation and establish a geothermal facility. It is also beneficial to engage economic and public consumer interest groups, community associations, and investors.

Therefore, we list the industries which use or need boreholes in Table 1, which is taken directly from the full Results Table (Appendix 6). The uses are similar throughout the countries. These sectors could be well owners/operators or potential heat customers.

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
▪ Oil and gas industry ▪ Agriculture ▪ Medical - Balneological ▪ Geothermal energy ▪ Food - Drinking Water, Botteling ▪ Mining ▪ Geological Research (Research Drilling)	▪ Oil and gas industry ▪ Agriculture (HE) ▪ Food - Drinking Water, Botteling ▪ Medical - Balneological ▪ Geothermal energy ▪ Geological Research (Research Drilling)	▪ Oil and gas industry ▪ Agriculture ▪ Medical - Balneological ▪ Geothermal energy ▪ Food - Drinking Water, Botteling ▪ Geological Research (Research Drilling)	▪ Hydrocarbon, underground storage (Gas) ▪ Mineral exploration ▪ Geothermal energy ▪ Geological Research (Research Drilling) ▪ Medical - Balneological ▪ Food - Drinking Water, Botteling	▪ Oil and gas industry ▪ Agriculture ▪ Medical - Balneological ▪ Geothermal energy ▪ Food - Drinking Water, Botteling ▪ Infrastructure ▪ Geological Research (Research Drilling)

Table 1: Industries which use deep wells.

5. Comparison of legal regulations and administrative procedures for well reuse in the TRANSGEO partner countries

5.1. Drilling regulations (Q8), usage of wells, and licensing of areas

The drilling regulations in each of the TRANSGEO partner countries are defined by the state's Mining Act and/or Water Act. As with all Tables in this Report, it is an excerpt from the full Results Table; further details can be found in each country's questionnaire (Appendices 1-5).

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
▪ A uniform system of rules for all industries and any kind of applications based on: ▪ Mining Law - XLVIII of 1993	▪ Act on the Exploration and Production of Hydrocarbons (*NN 52/18, 52/19, 30/21*)	▪ MINING ACT - Zakon o rudarstvu (ZRud-1), Uradni list RS, št. 14/14 - uradno prečiščeno besedilo, 61/17 - GZ, 54/22 in 78/23 - ZUNPEOVE ▪ WATER ACT - Zakon o vodah (ZV-1), Uradni list RS, št. 67/02, 2/04 - ZZdrl-A, 41/04 - ZVO-1, 57/08, 57/12, 100/13, 40/14, 56/15, 65/20, 35/23 - odl. US in 78/23 - ZUNPEOVE	▪ Mining Act ▪ Water Act ▪ Nature conservation	▪ Drilling a well > 300 m: same regulations for hydrocarbons, water or heat. ▪ Mining Act: MinroG (Mineralrohstoffgesetz) ▪ Water Act: WRG 1959 (Wasserrechtsgesetz)

Table 2: Legislative structure for drilling and using deep wells for production of water, hydrocarbons, and heat.

Licences for borehole production are based on resources in all countries. Therefore, it is important to determine whether something is defined as a resource or not (see Section 5.8.2).

In **Germany**, permits are required for resources such as hydrocarbons. If heat/brine is of interest due to a potential reuse, a new permit/licence is needed (Bundesberggesetz-BBergG). Other permits are also required, for example under the Mining Act (approval of the operating plan), the Water Act, the Nature Conservation Act, and by the Federal company for radioactive waste disposal ("Bundesgesellschaft für Endlagerung", BGE). The specific circumstances of each case will determine which permits are necessary.

In **Slovenia**, there are two possible processes for conducting research. The Mining Act applies to exploration drilling and other underground research. This Act provides guidelines and restrictions for conducting research in certain areas without limitations, as well as areas where limitations must be followed. The Water Act regulates investigations of underground waters, with exceptions for protected areas and flood zones. It is possible to drill anywhere except in these protected areas and flood zones. Following permit application, it may take several years to receive approval to change the legal function of the land so that geothermal activities are allowed to take place.

In **Croatia**, there is no legal distinction between drilling and using a well for different industries. The legal procedures for obtaining permits for drilling and well usage are governed by the Act on the Exploration and Production of Hydrocarbons (NN 52/18, 52/19, 30/21) and corresponding regulations.

In **Hungary**, the Mining Act - XLVIII of 1993 applies a unique system of rules to all industries and applications. As defined in version 01.03.2023 of the Act, Paragraph §5 states that the Mining Supervision Authority is responsible for authorizing the research, extraction, and utilization of geothermal energy through the extraction of thermal water. However, this excludes the extraction of thermal water for primarily medicinal

or agricultural purposes. Geothermal energy research can only be carried out with the permission of the Mining Supervision Authority.

In **Austria**, licences are required for the exploration and production of hydrocarbons, followed by drilling permits based on the Mining Act (MinroG). For water, there is no licence system available, and drilling permits follow the Water Act, which regulates the ownership of aquifers by the surface land owner.

While the **European Union** does not have specific legislation solely focused on drilling for hydrocarbons, its regulatory framework addresses the environmental and safety aspects of such activities within the broader context of energy policy and environmental protection. At the time of writing this document, there is no specific EU legislation dedicated to repurposing oil or gas wells.

5.2. Well status (Q10/Q11)

The well status (in production, shut-in, abandoned) and changes must be reported in all countries surveyed. Even though sometimes the records of well documentation are incomplete, there is at least one authority in every country which collects the data. In some countries, reporting has to be made to more than one organisation (e.g., **Slovenia**, **Croatia**).

The availability of public information varies from country to country (see Section 5.5). In **Hungary,** information on the status of wells is available for a fee, while in **Austria** no information is released to the public or companies. **Slovenia** and **Croatia** provide their data on request and for a fee if it is for economic purposes. In **Germany** a new federal law (Geologiedatengesetz, GeolDG) means that data reporting is mandatory; depending on the data classification, the data are either freely available, or not. The **European Union** does not collect any information/data related to hydrocarbon wells.

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
Data/status of well must be reported ▪ SARA (Supervisory Authority of Regulatory Affairs) ▪ Directorate of Geology into the GeoBank	▪ All data reported to Ministry of Economy and Sustainable Development ▪ Croatian Hydrocarbon Agency	For wells in production a report is mandatory; change of status must be reported to: ▪ Ministry of natural resources and space ▪ ARSO - Environmental Agency of Slovenia ▪ Directorate for Waters ▪ Mining Department	▪ Status must be reported to Mining Authority	▪ Status must be reported to Mining Authority
Information is publicly available at ▪ SARA (Supervisory Authority of Regulatory Affairs) Directorate of Geology from GeoBank ▪ Mining Property Utilization Nonprofit Public Ltd.	Well database accessible at: ▪ Croatian Hydrocarbon Agency - records about status not complete (for reserach free, for commercial pay)	Data can be accessed for a certain fee or upon request: ▪ company Petrol Geo ▪ partly government owned	▪ Data at mining authority ▪ State offices have access to view data	▪ No public information about well status or planned abandon-ments ▪ Annual report publication about total number of producing wells

Table 3: Overview of recent well status documentation and access by organisations or the public.

5.3. Well ownership (Q12)

In general, the first well owner is the company which was involved in the original drilling application or project, not the drilling operator. During operation, the wells are owned by the operator and/or licensee, if licences are available for the specific resource (see Section 5.8.2).

From this step onward, the situation differs from country to country.

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
▪ permit holder ▪ state owned (600)	▪ investor/company/ permit holder/ operator ▪ after that State of Croatia	▪ operator/investor ▪ state	▪ permit holder/ operator/investor ▪ state	▪ permit holder/ operator/investor

Table 4: Well owners in the 5 TRANSGEO partner countries.

In **Slovenia** the well is owned by the investor who financed the drilling. There are some abandoned wells which are neither on private or state-owned land and have no status of ownership.

In **Germany** the mining company ("Bergbauunternehmer") according to §4 paragraph (5) BBergG is a natural or legal person or partnership that performs or contracts all work to explore, produce, or process a natural resource and the land renaturation after these operations. It is the mining company that currently performs any of this work within an authorised plan of operations (Geothermieforum Niedersachsen, 2021).

In **Austria,** well ownership remains with the (first) operator until abandonment.

In all countries except Austria the state can overtake or overtakes automatically (e.g., **Croatia**) the well after licence expires.

5.4. Requirement to consider reuse of a well (Q18)

In development of national and transnational strategies, there is no obligation in any of the TRANSGEO partner countries to consider reuse of a well, in the case that a drilling project was not successful in its intended purpose. For example, in **Austria**, there is no requirement to demonstrate reuse for geothermal purposes where a well has been recently drilled and immediately abandoned without production, or after production but before abandonment (information based on personal communication with the Mining Authority). Such consideration for geothermal reuse of wells is viewed as a very important requirement that should be included in new strategic planning at national and EU scales.

5.5. Data availability (Q21) – Data restricted or open

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
▪ Basic well data are free ▪ Detailed data can be purchased through a one-stop system.	▪ Well data are partly free ▪ For academic aFnd research use all data are free	▪ Basic well data are free: name, location, depth	▪ Basic well data are free ▪ Other data dependent on type of data and age	▪ No data are free - restricted ▪ Webmap services of Mining Authority show hydrocarbon licence boundaries

Table 5: Data access for the public.

The systems concerning data availability differ within the partner countries (Table 5). The range spans from data restriction due to company rights (**Austria**) to nearly open access (**Hungary**).

Access is dependent on the type of data in several countries. For example, **Germany** has a law that explicitly defines the levels of access depending on whether the data are general location data, exploration and geological data, or other types. In **Croatia**, access depends on the intended use: Data are freely available for academic and research purposes but restricted for economic purposes. **Slovenia** freely provides basic data that can be used to generally characterise existing wells.

5.6. Data owner (Q22) and data storage (Q25)

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
▪ State, company: ▪ The mining contractor and state-owned SARA (Supervisory Authority of Regulatory Affairs) Directorate of Geology	▪ State	▪ Company ▪ Geological Survey ▪ State after concession expires	▪ Dependent on type of data/type of drillings: company, survey ▪ e.g. state drillings (research) are free	▪ Company ▪ Mining authority after licence abandonment

Table 6: Owners of well data and/or geological subsurface data.

Well data and reservoir data ownership varies through the region. In some countries data of recent exploration and abandoned licence areas is collected by the authorities, while other data is only archived by authorities when the reservoir is depleted and abandoned (e.g. **Austria**). In **Germany**, data ownership remains with the companies, which are obliged, depending on the type and age of the data, to make it available to the State Offices and Mining Authorities.

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
▪ Well database at state-owned Supervisory Authority of Regulatory Affairs (SARA) ▪ Database at Directorate of Geology in GeoBank	▪ Hydrocarbon Agency ▪ Geological Survey (backup)	▪ Company internal databases ▪ Geological Survey ▪ Mining Authority ▪ University ▪ Municipalities	▪ Company internal databases ▪ Federal States Databases: splitted or combined databases between Geological Survey and Mining Authority	▪ Company internal databases (OMV AG, RAG Austria, ADX Energy) ▪ GeoSphere Austria ▪ Mining Authority (only applications, reports, administrative decisions)

Table 7: Storage locations of well and geological databases.

It is also important for parties interested in geothermal development to know where geological and well data are stored. In each partner country data are stored by the owners, mostly in company databases. In **Croatia**, **Slovenia**, **Germany,** and **Austria** data are additionally stored at databases of the Geological Services and to some extent at the Mining Authorities. In **Hungary** the state-owned organisation, SARA and the Mining Property Utilization Nonprofit Public Ltd., store the data.

5.7. Well ownership transfer (Q29)

In cases where the recent well owner (mostly the operator of hydrocarbon production facilities) is not interested in a geothermal reuse option, municipalities, nearby industry, or others may be interested to pursue this development themselves. In this case, it is important to understand the procedures related to transferring well ownership and taking on the accompanying environmental, technical, safety, and other liabilities. Below, the regulation of ownership and liability are summarised.

Transfer of well ownership is possible in all countries except **Austria**. Here, transfer of ownership has been made if a new owner's purpose is hydrocarbon development. In this case, the new owner assumes ownership of not only a single well but rather everything within the active hydrocarbon licence area/field. For another usage, there are no regulations or examples in Austria. One reason could be that the recent owners have liability concerns (pers. comm. companies OMV AG and RAG Austria).

In the other countries, well ownership transfer is possible with certain obligations, which vary. In **Germany,** a transfer of well ownership means transfer to a new responsible mining company (Geothermieforum Niedersachsen, 2021). According to private law, the ownership and responsibilities of data, wells, drill site, etc. can be transferred. Specific attention has to be paid to the question of liabilities in these private contracts. The former mining company can be forced to explore potential contamination and remove it, but the liability for contaminations can also be transferred to the new mining company. On the other hand, the original mining company is always responsible for all mining damage caused by their activities. However, the reasons for mining damage can be difficult to determine such that both parties may eventually need to share responsibility. However, all these considerations are only required if the mining company actually changes. These kinds of liabilities make legal negotiations difficult and highlight the importance and the potentially high cost of insurance.

In **Slovenia**, transfer of well ownership is possible through a simple contract between two parties that defines the responsibility and the well. There are no legal obligations to consider.

Hungary has regulations for state-owned wells, in which the change of the ownership of a well is regulated by the State Property Act. If a well is not state-owned, the ownership rights can be transferred with a simple contract.

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
▪ In case of the state-owned wells the change of the ownership of a well is regulated by the State Property Act.	▪ Possible ▪ Transfer of rights and obligations can be partial or wholesome.	▪ Possible ▪ With a simple contract	▪ Possible ▪ Transfer of ownership with a contract	▪ Not applicable for single well (so far) ▪ Owner changes possible with employees and licence overtake

Table 8: Process of transferring ownership of a well.

5.8. Legal framework including definition of terms, licensing, and administration

5.8.1. Characteristics of geothermal energy (Q5)

In considering the reuse of wells as deep geothermal utilisations, it is important to define "deep" for geothermal use.

As shown in Table 9, there is no uniform definition of "geothermal depth" across the TRANSGEO partner countries, as all 5 countries use different depth intervals and/or temperature thresholds for geothermal use.

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
▪ no regulation ▪ deep geothermal when > 60°C	▪ no regulation	▪ > 300 m (different laws applicable)	▪ > 400 m is considered as deep well (Mining Authority is involved)	▪ No definition of depth available ▪ Mining Authority involved > 300 m

Table 9: Definition/regulation of geothermal energy based on depth.

5.8.2. Geothermal energy - raw material and ownership (Q33/Q34)

Since geothermal energy is not a material such as biomass or oil, its inclusion as a raw material is not obvious. Nevertheless, most TRANSGEO partner countries consider geothermal energy to be a raw material that is owned by the state. **Croatia** defines the water from which accumulated heat can be used as geothermal water owned by the state. In **Germany,** geothermal energy is considered a resource, and brine (which can transport the geothermal energy to the surface) is considered another resource. Therefore, in closed geothermal systems, only one licence is required (for geothermal energy) and in open geothermal systems, two licences are required (one for geothermal energy and one for brine). The exception is **Austria** which has no consideration of geothermal energy and its ownership.

HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
▪ Yes, mentioned and described by the mining act as geothermal energy	▪ Not a raw material, but geothermal water is defined as water from which accumulated heat can be used	▪ Geothermal heat is defined as raw material in case the Mining law is applicable and a 100% reinjection rate is established.	▪ Yes and it is categorised as "Bergfreier Rohstoff" which means it is a resource free for mining	▪ No, geothermal heat is not considered a raw material or mentioned in any other ways
▪ State property in its natural place of occurrence and below 150 m depth ▪ regulated by the Mining Act	▪ State property in its natural place of occurrence and below 150 m depth, regulated by the Mining Act	▪ State property ▪ regulated by the Mining Act	▪ State property ▪ regulated by the Mining Act	▪ No ownership as heat is not considered as a resource ▪ Ownership and use are indirectly regulated by the Water Act

Table 10: Definition of geothermal energy as a resource. Information about resource ownership.

5.8.3. Licence process (Q36 ff.)

In this section, we outline the well licensing procedure for each of the 5 TRANSGEO partner countries. The process of applying for a geothermal project is different in each country and usually depends on the intended purpose of the well. Table 11 provides an overview, and the following sections provide workflow diagrams and application requirements for project evaluation, licence application, drilling and surface equipment, and identify the authorities involved at each step. The focus is on reuse of wells, thus new drilling applications are marked as optional steps, as it is assumed that for reuse, drilling plays a minor role. Note that applications for user facilities, such as above-ground infrastructure for agriculture, and information on regulations related to specific operation, such as agriculture or economic use, are excluded.

Question	HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA
Entities involved in the licensing procedure	▪ SARA Mining Supervision Authority	▪ Ministry of Economy and Sustainable Development ▪ Croatian Hydrocarbon Agency	▪ Ministry of natural resources and space ▪ ARSO - Environmental Agency of Slovenia ▪ Directorate for waters, Direktorat za vode ▪ Mining department, Sektor za rudarstvo	▪ Mining Authority ▪ Water Authority (regional) ▪ State Agency for Environment (Landesamt für Umwelt) ▪ District (Landkreis - several authorities: monuments, archaeology, forestry, regional planning, military, etc) ▪ BASE - Endlager ▪ Nature Conservation Associations (voluntary but strategically necessary)	▪ Approval related to the Water Act: Water Authority at local (districts) or regional (federal state) level ▪ Mining Act: national level (Mining Authority)

Table 11: Entities involved in the licence procedure.

5.8.3.1. Idealised project workflow for geothermal projects in Hungary

In Hungary a licence system is established and the whole approval process is covered by a one-stop shop system. A detailed description can be found in Appendix 1.

To apply for a geothermal licence, the first step is to obtain a research licence from SARA. This licence applies to the area designated and not to the wells. After the completion of a successful research project,

the licence holder has to sign a contract with SARA for geothermal production which defines the geothermal licence area, preventing others from withdrawing water from that zone.

Next, the application process follows one of two paths, depending on whether the licence holder will drill a new well or reuse an existing well. According to the law, for an existing well, the licence holder must apply for a permit from SARA to conduct a well test. If the test if successful and the existing well is appropriate for reuse for geothermal energy, then the licence holder must acquire the ownership rights to the well. If the well is state-owned, the well may be rented or purchased. Both processes take at least 4 to 8 months. If the abandoned well is not state-owned, the ownership rights can be transferred with a simple contract.

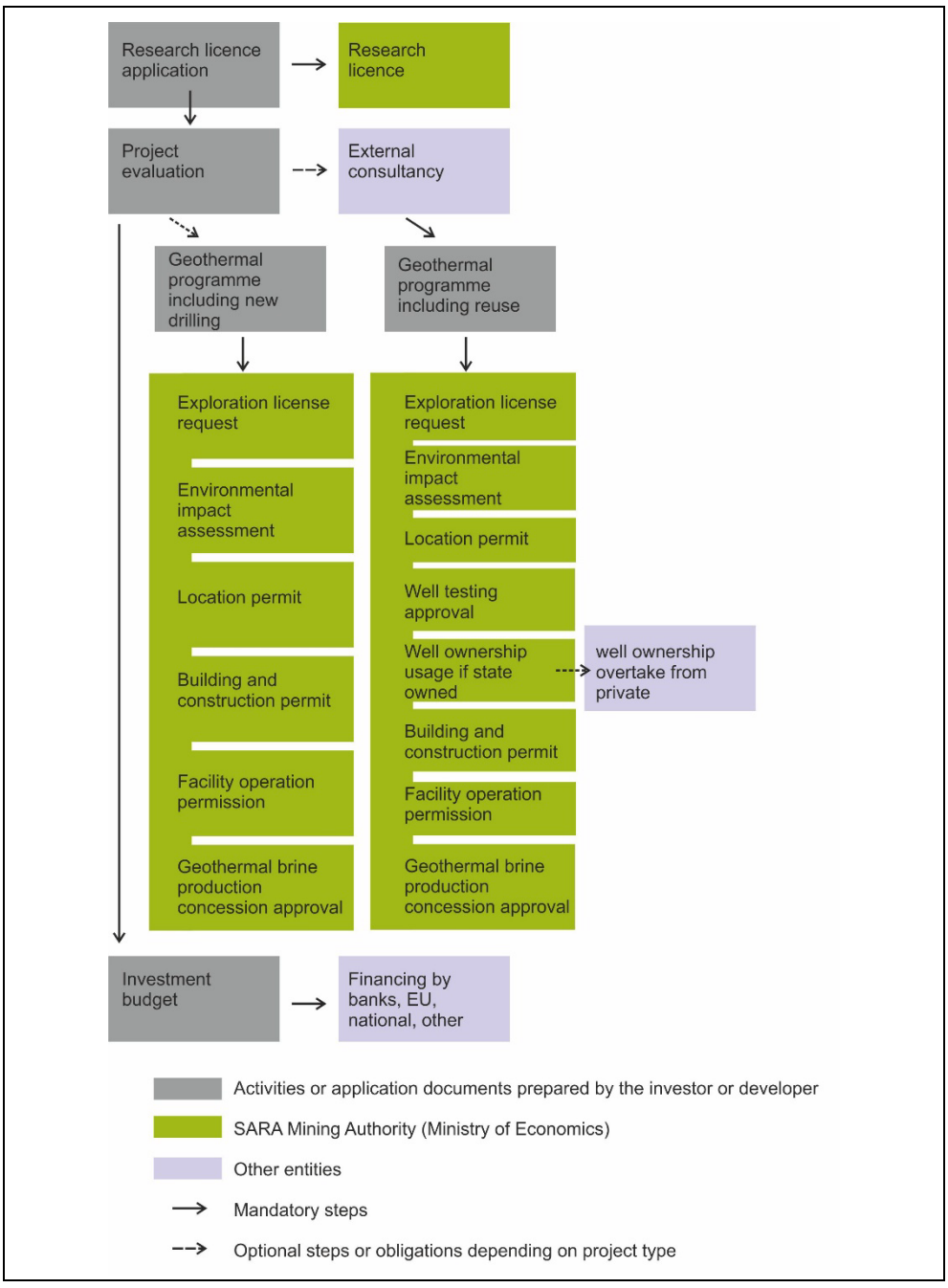


Figure 5: The Hungarian geothermal licencing procedure for new drilling projects and reuse of old wells. This process is defined in Hungary by law.

5.8.3.2. Idealised project workflow for geothermal projects in Croatia

The geothermal policy framework in Croatia includes a licence process for acreages and separate applications for project execution within 3 Ministries: Mining Authority within Ministry of Economics, Ministry of Environmental Protection, and Ministry of Construction and Physical Planning. For further detail, see Appendix 4.

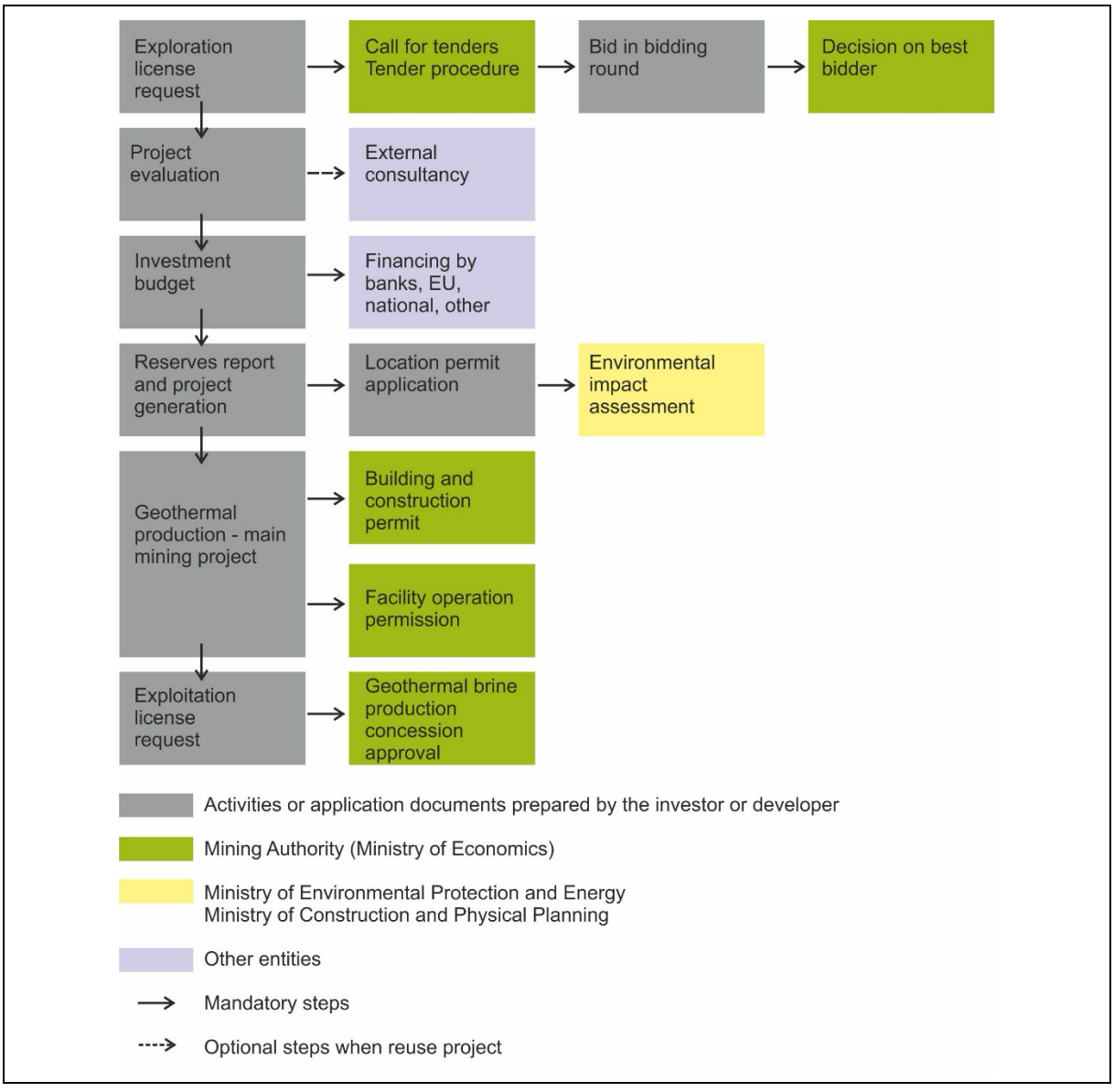


Figure 6: Example of the licence procedure in Croatia for using geothermal brine, divided into project steps and involved authorities (modified after Karasalihović Sedlar et al., 2022). There is no explicit process for reuse defined, so the legal requirements are taken from the regulations for geothermal workflows and permitting in Croatia.

5.8.3.3. Idealised project workflow for geothermal projects in Germany

In **Germany,** the geothermal application and project development process includes the Mining Authority and federal state offices for water and environmental approvals. There exists a licence system for geothermal applications but there is not explicit regulation for reuse. A report on reuse of unused wells by the Geothermieforum Niedersachsen (2021) provides detailed information on legal topics concerning reuse in Germany. The details of the TRANSGEO questionnaire can be found in Appendix 3.

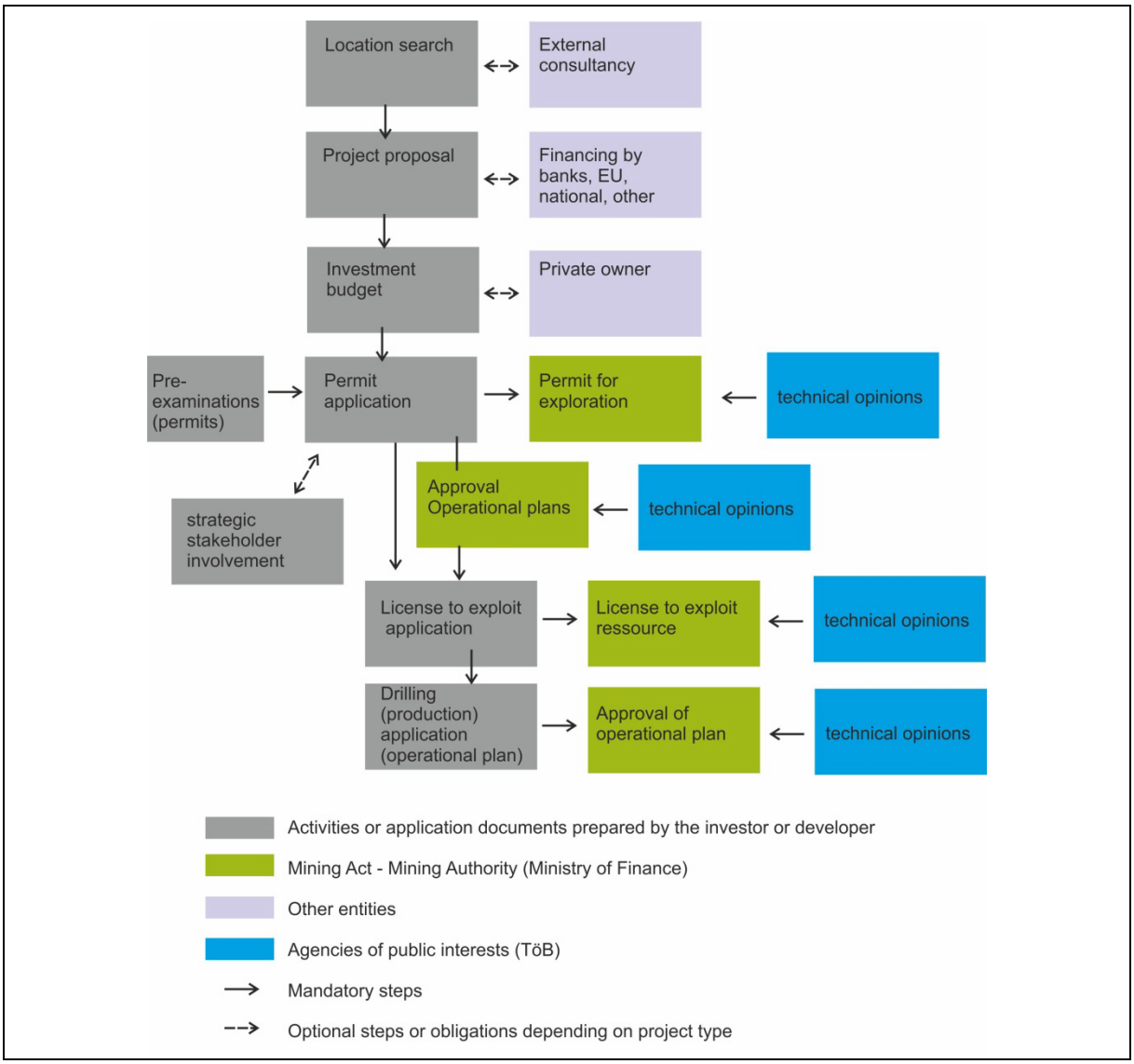


Figure 7: The licence procedure for geothermal (drilling) projects in Germany. The reuse of old wells is not explicitly regulated. TöB = Träger öffentlicher Belange (public interest organisations).

5.8.3.4. Idealised project workflow for geothermal projects in Slovenia

The Slovenian licence procedure includes 3 different agencies located in 2 Ministries. The process is under the supervision of the Inspectorate of Natural Resources and Mining, which is responsible for new and abandoned wells. For further detail, please see Appendix 2.

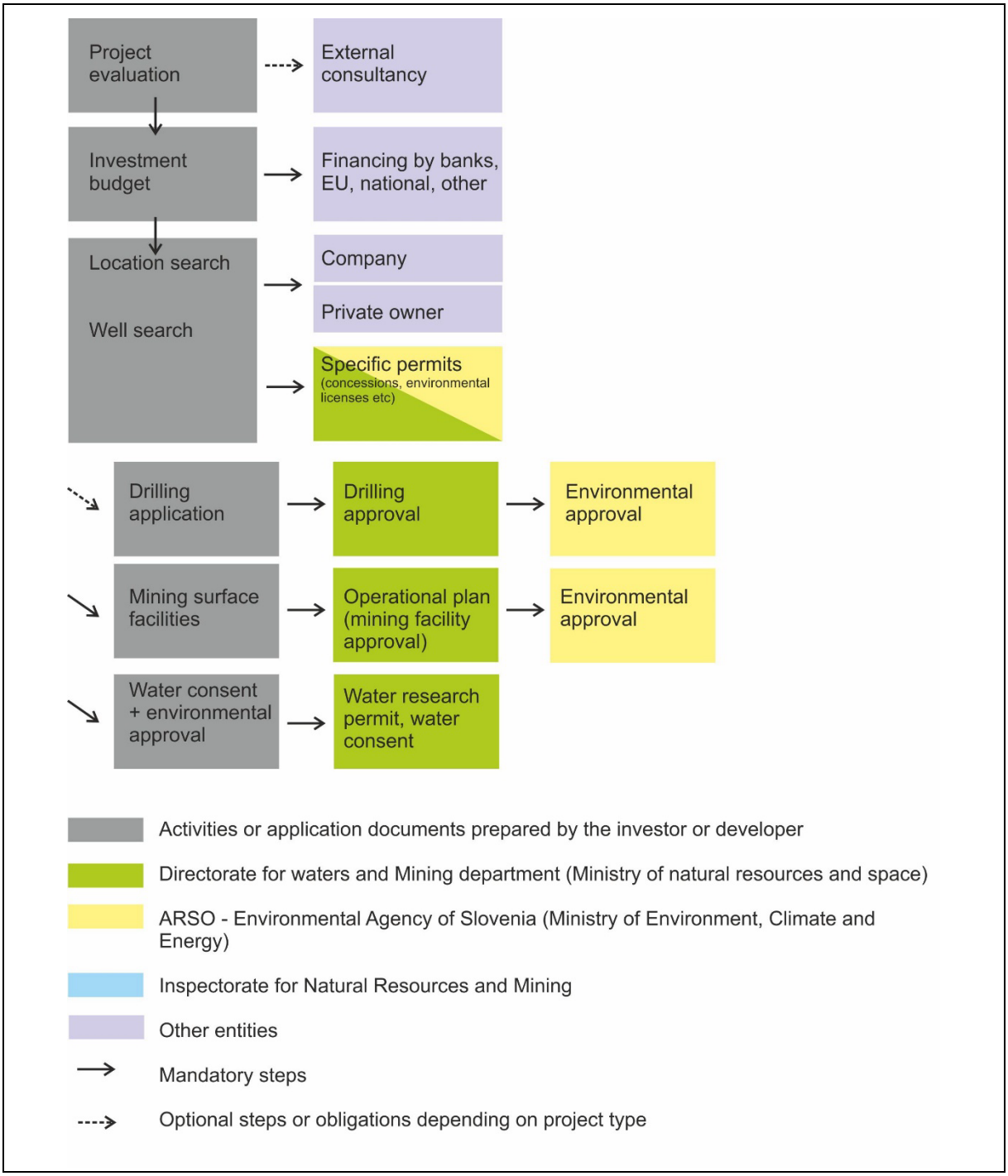


Figure 8: Project workflow for Slovenia including the licence procedure for geothermal (drilling) projects. The optional steps (e.g., drilling application) should show the emphasis on well reuse, where drilling may not be required. For reuse projects no distinct application process is defined in Slovenia, so the legal requirements are taken from the regulations for deep drilling and the operation of mining facilities.

5.8.3.5. Idealised project workflow for geothermal projects in Austria

Austria does not have a licence system for (hydrothermal) geothermal areas. The process is mainly covered by regulations of the Mining Authority (e.g., drilling) and the Water Act which is valid for applications using thermal waters. Closed systems, like deep borehole heat exchangers, are excluded from the Water Act. For further detail, see Appendix 5.

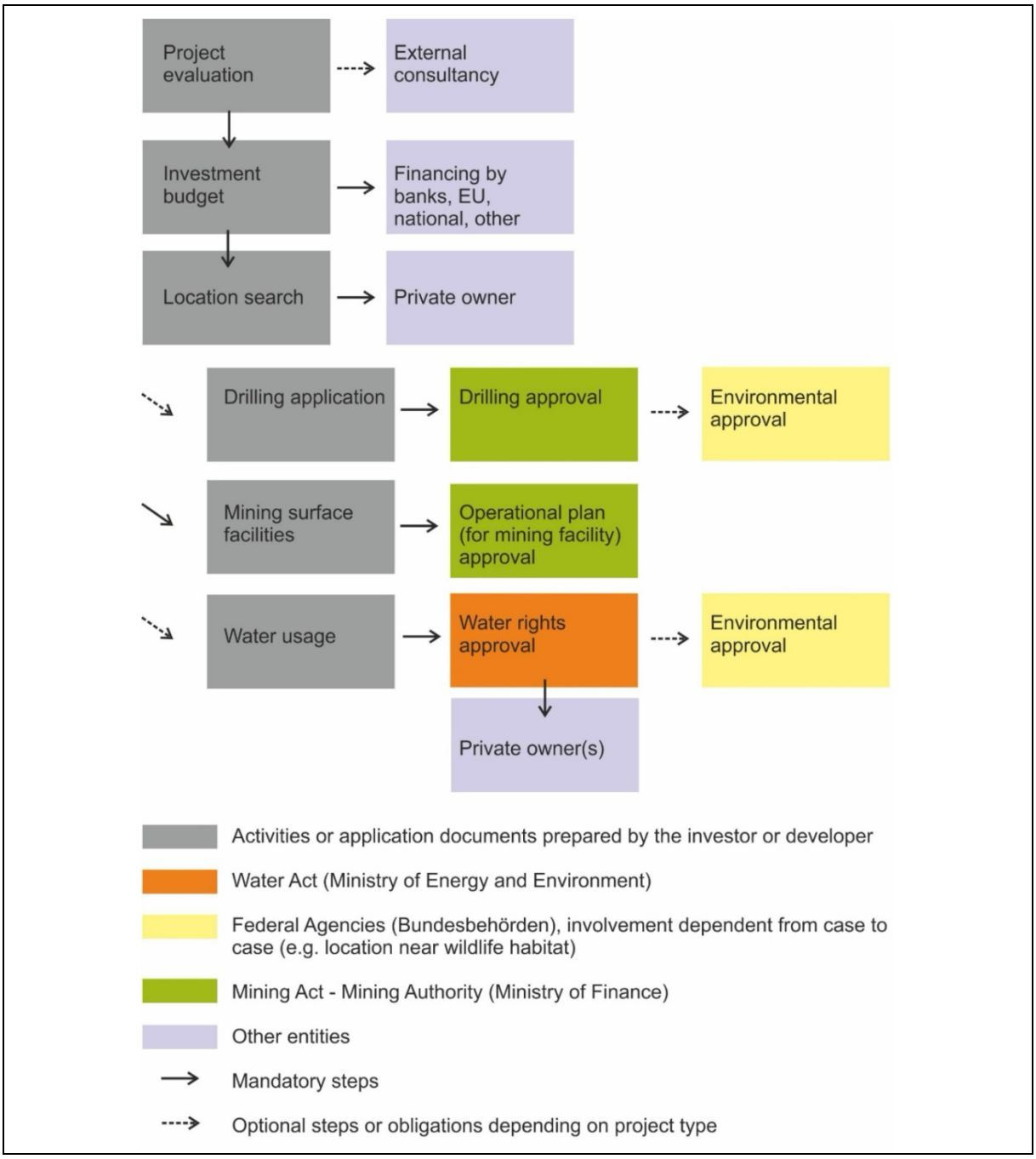


Figure 9: Project workflow including permitting procedure for geothermal (drilling) projects in Austria. The optional steps (e.g., drilling application) should show the emphasis on well reuse where drilling may not be required. As there is no explicit legal regulation for well reuse, the workflow is put together from regulations for drilling and production of wells deeper than 300 m depth.

5.8.4. One-stop shop systems and/or online application (Q48/49)

For the implementation of reuse projects, a clearly defined administrative framework and user-friendly application processes are needed. As online options are changing rapidly, the systems vary in the partner countries.

Slovenia, **Croatia,** and **Austria** do not provide a one-stop shop system. The application procedures depend on the purpose of the projects and locations.

In **Hungary**, a one-stop shop has existed since 1 March 2023. It creates an efficient and fast administration. Extraction and utilization of geothermal energy can be performed based on a contract with the Mining Supervision Authority.

In **Germany** the procedure differs from project to project. In some cases, the mining authority handles the different approvals, such as in the case of the licence. In other cases, it may be necessary to obtain approvals from other authorities as well with a separate application (e.g., nature conservation authority). Theoretically, the State Ministry of Economics could function as a one-stop shop, but at the moment, no central, streamlined system exists.

Online applications are possible in **Slovenia** and **Hungary**. In Hungary you can only apply online, and in Slovenia, both online and analogue applications are possible. In Slovenia the online application process is often used, because the applicant can immediately get the confirmation of receipt and it is faster and easier for document filling. **Croatia**, **Germany,** and **Austria** do not provide an online system. In Germany, an online service is planned in the near future.

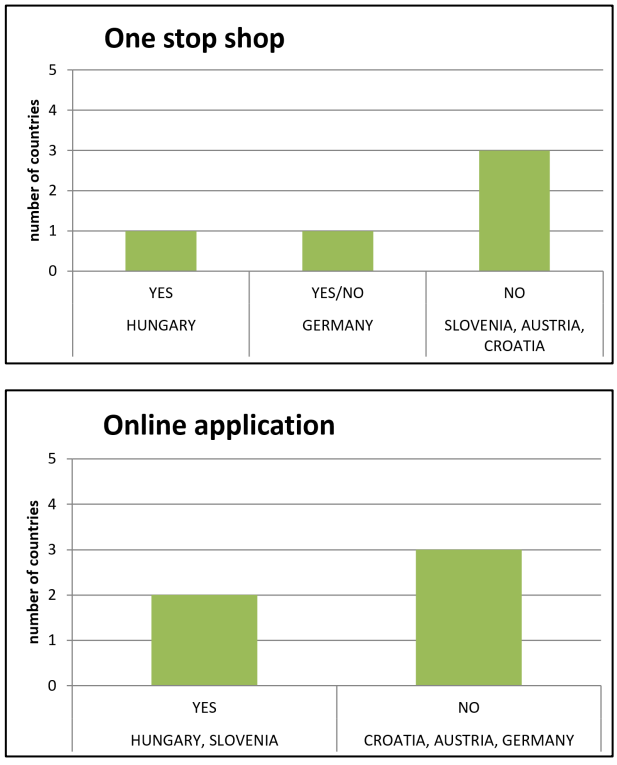


Figure 10: Overview of the existence of one-stop shop systems and online application facilities within the TRANSGEO partner countries. For details see text.

6. Comparative studies on the financial framework and funding opportunities for well reuse in the TRANSGEO partner countries

6.1. National funding (Q53)

In **Austria,** national funding for reuse of existing wells is explicitly mentioned in the funding regulations of the Kommunalkredit Public Consulting (KPC, 2024; p11).

In **Slovenia,** exclusive financial resources for applied use of geothermal energy from existing wells do not exist. Indirect financing of the project in the form of traditional or innovative financial instruments are applied (e.g., subsidies, tax relief, and grants that are in the domain of the ministries).

In **Croatia,** there are no strictly-defined national funds that can be used for geothermal applications and projects with the aim of exploring and reusing existing wells. Instead, such projects are financed by alternative schemes such as European and Norwegian grants and national funding. This funding is divided into the following categories: preparation and research of geothermal potential in the context of centralized heating, increasing capacity for geothermal energy production, creating a database of deep geothermal energy, and creation of technical documentation for the use of geothermal energy.

In **Hungary,** a new national funding program has existed since March 2024, when a new call for proposals was opened under the Swiss-Hungarian Cooperation Programme II. Under the tender, it is possible to modernise or refurbish existing active, closed, producing, or recovering thermal wells and to convert barren, state-owned hydrocarbon wells with geothermal potential, which were not in use when the tender was announced, into a thermal well order to increase sustainable geothermal energy production (SWISS Hungarian Cooperation programme, 2024).

In **Germany**, there is no specific national funding programme for geothermal applications based on reuse of existing wells. Federal funding guidelines may allow existing boreholes to be used (depending on the specific program provider). The amounts and who can apply for the funds also depend on the specific program (see detailed list in Appendix 3).

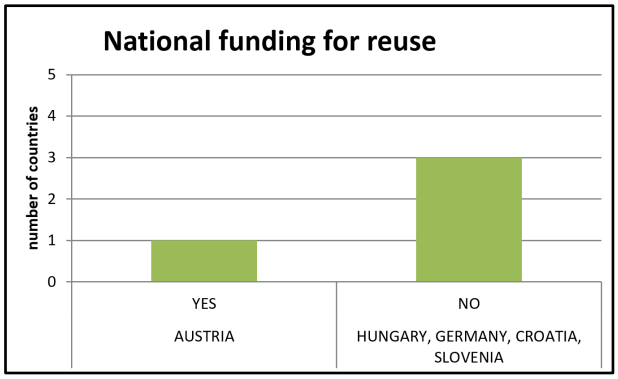


Figure 11: Distribution of national funding in the partner countries. For Croatia there are international programmes available which include partial national support.

6.2. Traditional and innovative financing options (Q55)

We consider traditional funding versus innovative or alternative funding based on a scheme of the project SAPHEA financed by the European Geothermal Energy Council (EGEC) (SAPHEA Project homepage, 2024).

	Traditional	Innovative	
Non Repayable	Prizes, Subsidies and Grants Tax incentives	Energy Efficiency Feed-in Tariff	
Debt	Loans / Mortgages Credit Enhancers: Guarantees, Securities, Insurances, Additional Collateral, etc.	Green Loans / Soft Loans Green Bonds, Community/ Municipal Investment Bonds, Social Bonds Energy Performance Contracting (EPC) / Agreements (EPA)	Energy Service Agreement (ESA) Green Leasing, PACE Energy Efficient Mortgages On-Bill Financing Loans / Tariff Green Revolving Funds Crowdfunding
Equity	3rd Party Funding (Business Angels)	Energy Communities, Energy Cooperatives	
Other	Advisory Services Technical & Project Dev. Assistance Capacity Building	Energy Efficiency Quota Obligations One-Stop Shops	

SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

Figure 12: Comparison of traditional and innovative funding based on a definition of the Horizon Europe project SAPHEA financed by the European Geothermal Energy Council.

In **Germany**, the financial options include both traditional and innovative funding. The traditional options include subsidies of a percentage of the project costs, grants, and tax incentives. Innovative funding is supported by the "Law for the expansion of renewable energies" which gives incentives for "green" electricity (including geothermal energy) and support for heat pumps (Bundesministerium der Justiz (2024): Gesetz für den Ausbau erneuerbarer Energien (in German)).

Traditional instruments in **Croatia** include grants based on external financing programmes, subsidies, and loans from national banks. Alternative instruments such as Energy Performance Contracting (EPCo) or crowdfunding exist for electricity generation, but they are not based explicitly on geothermal energy or well reuse.

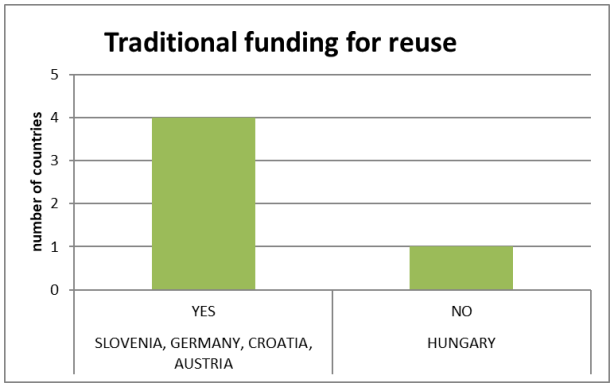


Figure 13: Funding schemes defined as "traditional" exist in most partner countries.

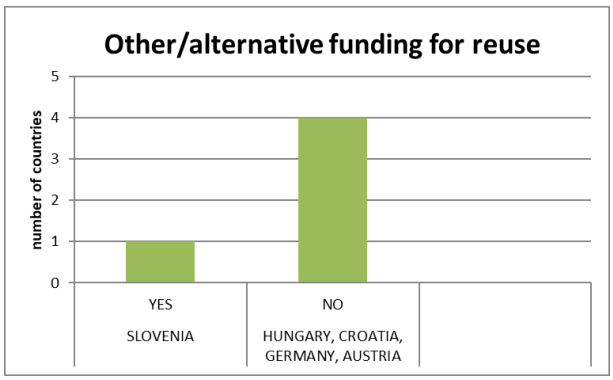


Figure 14: Existence of other types of funding, like crowdfunding or energy communities, within the partner countries.

6.3. European Union funding (Q56)

There is not a specific funding program of the **European Union** exclusively dedicated to geothermal energy. However, while there are no programs solely for geothermal, some initiatives have components or funding streams that can support geothermal energy projects alongside other renewable energy sources.

Some of the key funding opportunities for geothermal energy include:

Horizon Europe: Horizon Europe is the EU's flagship research and innovation funding program for the period 2021-2027. Within Horizon Europe, geothermal energy projects may be eligible for funding under several thematic areas, including the "Climate, Energy, and Mobility" cluster. Horizon Europe supports research and innovation activities aimed at advancing geothermal technologies, improving efficiency, and reducing costs.

European Structural and Investment Funds (ESIF): The EU provides funding through the European Structural and Investment Funds, including the European Regional Development Fund (ERDF), the Cohesion Fund, and the European Social Fund (ESF). These funds aim to reduce economic disparities between regions and support sustainable development initiatives. Geothermal energy projects may receive funding from ESIF for infrastructure development, research and innovation, and energy efficiency improvements.

Innovative Financing Instruments: The EU offers innovative financing instruments to support geothermal energy projects, including loans, guarantees, and equity investments. For example, the European Investment Bank (EIB) provides loans and financing for renewable energy projects, including geothermal energy installations. The European Bank for Reconstruction and Development (EBRD) also offers financing and technical assistance for sustainable energy projects in countries within its operational mandate.

European Regional Development Fund (ERDF): The ERDF, which is part of the **European Structural and Investment Fund (ESIF)**, supports investments in renewable energy infrastructure, including geothermal energy projects, in regions across the EU. Funding from the ERDF may be used for the construction of geothermal power plants, district heating and cooling systems, and research and development activities. TRANSGEO is supported by ERDF, through Interreg Central Europe.

European Investment Fund (EIF): The EIF, which is part of the European Investment Bank Group, provides risk finance to support innovation, entrepreneurship, and sustainable development. Geothermal energy projects may benefit from EIF financing through venture capital funds, guarantees, and other financial instruments.

InnovFin Energy Demonstration Projects: This initiative, supported by the European Investment Bank (EIB) and the European Commission, provides financing and advisory services for innovative energy projects, including geothermal energy demonstration projects. It aims to accelerate the commercialization and deployment of new renewable energy technologies.

NER 300: Although not exclusively for geothermal energy, the NER 300 program provides funding for innovative renewable energy and carbon capture and storage (CCS) demonstration projects. Geothermal projects with innovative technologies or applications may compete for funding under this program.

Interreg: While also not providing specific funding for projects relating to geothermal energy, Interreg is a key EU instrument that strengthens cooperation between regions and countries within the EU, focusing on addressing current challenges like climate change, digital transformation, and social inclusion. Under this umbrella, Interreg Central Europe funds projects that make Central Europe more resilient to challenges that know no borders and cannot be solved alone. One of its priorities is to facilitate cooperation for a greener Central Europe, helping to increase energy efficiency and the use of renewable energy. Within this context, Interreg Central Europe (CE) funds projects like this TRANSGEO project, which investigates transforming abandoned hydrocarbon wells for geothermal energy production (Interreg Central Europe homepage, 2024; Interreg Europe homepage, 2024).

These are just a few examples of the funding opportunities available from the EU to support geothermal energy projects. The specific eligibility criteria, application processes, and funding amounts may vary depending on the program or initiative. While these funding opportunities are not exclusive to geothermal energy, they provide avenues for geothermal projects to access financial support and accelerate their development and deployment.

6.3.1. Other funding within the TRANSGEO partner countries including EU funding (Q56)

In **Hungary,** the most important funding related to energy efficiency are non- or partly-refundable support schemes, outlined in the Operational Programmes (OPs), financed by EU Funds. The explicit focus of the 5th priority axis of the Environmental and Energy Efficiency Operative Programme (KEHOP) is improvement of energy efficiency, combined with the development of renewable energy solutions in public buildings, the development of heating systems, including district heating, and increasing awareness. The Territorial and Settlement Operational Programme (TOP) finances energy efficiency upgrades at local authorities. The Economic Development and Innovation Operational Programme (GINOP) has also sub-programmes that aim to promote energy efficiency in the enterprise sector and also financed a residential zero-interest loan scheme operated by the state-owned Hungarian Development Bank. In Hungary, EEA (European Environmental Agency) and Norway Grants (https://eeagrants.org/) play a major role for investments in geothermal. For further detail, see Appendix 1.

Croatia uses several European support options whose priority objectives are related to energy efficiency, renewable energy sources, and transition away from and reduction of CO_2 emissions (decarbonisation), while at the same time, encouraging strong cross-border and transnational cooperation among EU and non-EU states. Some of the most significant financing options applicable for Croatian green and alternative energy projects, as well as their activities related to renewable energy sources (including geothermal) are: Interreg Central Europe (Interreg Central Europe homepage, 2024), Interreg IPA Croatia, Bosnia and Herzegovina, Montenegro (Interreg IPA Croatia, Bosnia and Herzegovina homepage, 2024), Innovation Fund (Innovation Fund homepage, 2024), and the Modernisation Fund (Modernisation Fund homepage, 2024). Further details are available in Appendix 4.

Projects in **Germany** are supported by the European Investment Bank (EIB) and the European Fund for Strategic Investment (EFSI), through an investment of 315 Mio. € in “riskier” projects which might cover exploration wells and compensate cases of failure (see Appendix 3.)

6.4. Other financial incentives (Q57)

If there are financial incentives for companies to locate in regions where abandoned wells are situated, such support could dramatically improve the rate of project generation and initiation. **Hungary** provides an example of this type of program, where the location of the investment, rather than the location of the company, determines the level of support. Financial incentive may be increased by 10% and 20%, respectively, for medium-sized and small enterprises which invest in the regions of Northern Hungary, Northern and Southern Great Plain, and Southern, Central, and Western Transdanubia. Other TRANSGEO partner countries do not yet provide financial incentives to support companies in establishing themselves in regions with geothermal energy potential.

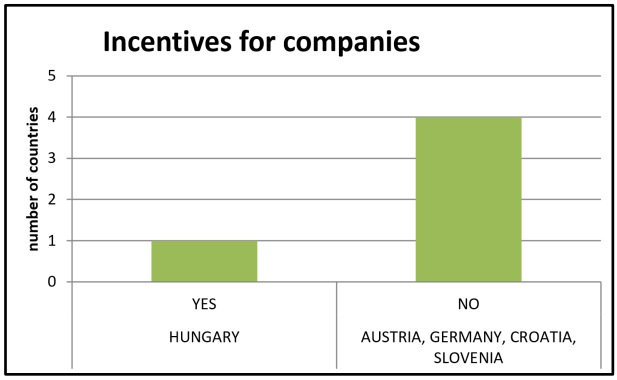


Figure 15: Presence of regional subsidies for companies to undertake activities in certain regions. For TRANSGEO, this focuses on regions of former hydrocarbon production ("hydrocarbon provinces").

6.5. Integration of well reuse in regional strategic planning (Q58)

To provide strategic recommendations through the TRANSGEO Transnational Strategy (Deliverable 3.2.1. expected 2025), we inventoried development plans and strategic policies and activities related to boreholes and explored their applicability to well reuse. In all partner countries, there are no specifically defined strategic development plans for the use of existing wells. However, there are regional development plans in every partner country focusing on district heating based on hydrothermal energy.

In **Germany**, strategic planning is in development and geothermal energy use is already part of mandatory municipal heat planning. In some cases, reuse of old wells is being included.

For **Slovenia,** there are no specifically defined strategic development plans for the use of existing wells. One possibility for addressing reuse of wells is within certain mining projects which may include rehabilitation of wells through definition of the status of all wells in a specific mining area.

In **Croatia**, each county draws up its own strategy or plan with detailed development areas and potential projects in the field of energetics and energy production, including consideration of geothermal energy projects in counties with such potential.

7. Conclusions

The “Report on Regional Comparison of Policy Frameworks for Well Repurposing” by the TRANSGEO project partners examines how Germany, Austria, Hungary, Croatia, and Slovenia manage the legal, administrative, and financial aspects of repurposing wells. This report aims to accelerate the development of strategies to promote the reuse of abandoned hydrocarbon wells.

Based on our research, we conclude that the role of reuse in the alternative energy market appears to be minor, as inferred from the political significance and current or proposed projects.

Regulations, documentation for drilling deep wells, and environmental standards are similar in the partner countries. The on-going presence of hydrocarbons may explain the current lack of interest in this topic, but this is likely to change as hydrocarbon production declines.

A major concern is the accessibility of data. In general, data are available and well documented in all of the TRANSGEO partner countries, but the rules related to making these data accessible to the public vary greatly, ranging from very restrictive to open data policies. Access to the data also depends on who is requesting it, with academia and researchers often having free access while companies may have to pay.

Legal issues, such as the transfer of ownership of wells, are also handled differently in each partner country. Projects will be easier to realise in countries where ownership changes can be made more easily. Transfer of ownership is possible in all partner countries except Austria.

The application and permitting process for geothermal projects varies from country to country. Some countries have implemented one-stop shop systems and online application tools which could serve as examples for others. The one-stop shop in Hungary seems to be the simplest application system as one authority handles all applications and approvals.

While funding for reuse projects is limited, the majority of funding is for geothermal energy projects that include drilling new wells. However, the cost savings of not drilling new wells can make reuse projects more attractive, even without supporting financial incentives.

Overall, it seems that there are few political, legal, or financial obstacles preventing successful reuse of existing wells for geothermal purposes. Indeed, this has been borne out by a number of initial reuse projects in the five TRANSGEO partner countries. However, it is worth noting that there is considerable variation in the number of projects, the political integration, the legal frameworks, and the financial support available between countries. This suggests that continued cooperation and the development of comprehensive strategies are essential to improve the conditions for the reuse of hydrocarbon wells for geothermal energy production and storage in central Europe.

8. References

- ATES Vienna Project homepage (2021), accessed 30 June 2024, <https://projekte.ffg.at/projekt/3849155>
- Bundesministerium der Justiz (2024): Gesetz für den Ausbau erneuerbarer Energien, accessed 30 June 2024, <https://www.gesetze-im-internet.de/eeg_2014/index.html#BJNR106610014BJNE020303311>
- Bräuer, L. (2011): Geothermie aus bestehenden Sonden, Blue Globe Report-Erneuerbare Energien #26/2011 Klima- und Energiefonds
- Doppelreiter, D. (2012): Geothermische Nachnutzung der Kohlenwasserstoffbohrung Mühlleiten 2, Oberösterreich. Abstract Pangeo 2012
- Doppelreiter, D. (2014): Tiefe Erdwärmesonde Mühlleiten 2 – Nachnutzung einer nichtfündigen Kohlenwasserstoffbohrung; Vortrag auf dem Workshop „Tiefe Erd-wärmesonden und Energiespeicherung in Aquiferen“ des Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg am 23.06.2014 in Stuttgart, Germany
- EEA (European Environmental Agency) and Norway Grants Fund, accessed 30 June 2024, <https://eeagrants.org/>
- Federal Ministry for Economic Affairs and Climate Action – Press Release (2022), accessed 30 June 2024, <https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2022/11/20221111-geothermal-energy-for-the-heat.html>
- Geothermieforum Niedersachsen (2021): Geothermische Nachnutzung von Bohrungen, accessed 30 June 2024, https://www.lbeg.niedersachsen.de/download/115995/Geothermische_Nachnutzung_von_Bohrungen_2021_.pdf
- Innovation Fund homepage, accessed 30 June 2024, <https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund_en>
- Interreg Central Europe homepage, accessed 30 June 2024, <https://www.interreg-central.eu>
- Interreg Europe homepage, accessed 30 June 2024, <https://interreg.eu>
- Interreg IPA Croatia, Bosnia and Herzegovina homepage, accessed 30 June 2024, <https://interreg-hr-ba-me.eu/>
- Karasalihović Sedlar, D., Kurevija, T., Macenić, M., & Smajla, I. (2022). Regulatory and economic challenges in the production of geothermal brine from a mature oil field. Energy Sources, Part B: Economics, Planning, and Policy, 17(1), 2097336.
- Kommunalkredit Personal Consulting - KPC (2023): Informationsblatt Förderungsberechnung, accessed 30 June 2024, <https://www.umweltfoerderung.at/fileadmin/user_upload/umweltfoerderung/uebergeordnete_dokumente/_infoblatt_foerderungsberechnung.pdf>
- Kommunalkredit Personal Consulting - KPC (2024): Informationsblatt Nahwärmeversorgung, accessed 30 June 2024, https://www.umweltfoerderung.at/fileadmin/user_upload/umweltfoerderung/betriebe/Nahwaermeversorgung/ufi_standardfall_infoblatt_biofern.pdf
- Modernisation Fund homepage, accessed 30 June 2024, <https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/modernisation-fund_en>

- SAPHEA Project homepage (2024), accessed 30 June 2024, <https://gogeothermal.eu/projects/saphea/>; EGEC, the European Geothermal Energy Council
- SWISS Hungarian Cooperation programme (2024), accessed 30 June 2024, https://svajcialap.hu/en/news/call-for-proposal-sm06-geo-geothermal-energy-for-district-heating-programme
- Tuschl, M., Kurevija, T., Krpan, M., & Macenić, M. (2022). Overview of the current activities related to deep geothermal energy utilisation in the Republic of Croatia. Clean Technologies and Environmental Policy, 24(10), 3003-3031.

9. Other resources used

- Interreg RuGeoHeat (2019) - Report on funding possibilities of geothermal projects; Internal report, accessed 30 June 2024, <https://www.interregeurope.eu/sites/default/files/2022-11/Report%20on%20INTERREG%20IVC%20project%20study.pdf>
- Interreg GEOPLASMA (2017) – SUMMARY OF NATIONAL LEGAL REQUIREMENTS, CURRENT POLICIES AND REGULATIONS OF SHALLOW GEOTHERMAL USE; Internal report, accessed 30 June 2024, <https://programme2014-20.interreg-central.eu/Content.Node/GeoPLASMA-CE/CE177-GeoPLASMA-CE-D.T2.4.1-Summary-of-national-legal-requir.pdf>
- Lunjkovec-Kutnjak Decision on granting the exploitation field licence (2023), accessed 30 June 2024, <https://delekovec.hr/images/Rje%C5%A1enje_o_utvr%C4%91ivanju_EPG_Lunjkovec-Kutnjak.pdf>, in Croatian
- Mineralrohstoffgesetz (Gesamte Rechtsvorschrift), Fassung vom 19.01.2024 - Bundesgesetz über mineralische Rohstoffe (Mineralrohstoffgesetz – MinroG) *) StF: BGBl. I Nr. 38/1999 (NR: GP XX RV 1428 und Zu 1428 AB 1527 S. 152. BR: 5817 AB 5818 S. 647.) [CELEX-Nr.: 396L0061, 396L0082, 392L0091, 392L0104]; in German
- Pranckh, H. (2008) - Gewässerschutz im Bergrecht–wasserrechtliche und mineralrohstoffrechtliche Bewilligungspflichten für eine Bergbauanlage; Diplomarbeit; Universität Graz; in German
- PwC & Nimbuc (2023) – Potenziale nachhaltiger Wärme aus Geothermie für Gemeinden, Industriebetriebe und Energieversorgungsunternehmen, accessed 30 June 2024, https://www.pwc.at/de/publikationen/pwc-geothermie-in-oesterreich_2023.pdf; in German
- ThinkGeoenergy (2022): Bukotermal started exploration work on an existing well for the Kutnjak geothermal project in Croatia during exploration field phase, accessed 30 June 2024, <https://www.thinkgeoenergy.com/exploration-started-for-bukotermal-kutnjak-geothermal-project-in-croatia/>
- ThinkGeoenergy (2023): British Star Energy mobilizes rig to Ernestinovo geothermal site in Croatia, accessed 30 June 2024, <https://www.thinkgeoenergy.com/british-star-energy-mobilizes-rig-to-ernestinovo-geothermal-site-in-croatia/>

10. Terminology

Active (or producing) well	A well that is currently in use, producing fluids (gas, oil, or water).
Application	An application includes the documents to be submitted to an agency or agencies which regulate activity in a specific jurisdiction, in order to obtain a permit or a licence. A person can apply to the regulator for an oil and gas or water permit by submitting an application in the form and manner required by the regulator. An application can include one activity or more activities submitted as a bundle. The application must include specific legal locations and detailed technical information with all other required information for all the activities included in order for the application to be reviewed and a determination made.
Inactive (shut-in) or temporarily abandoned well	A well where production, injection, disposal, or workover operations have ceased, but permanent abandonment has not taken place. Inactive wells should be classified as either shut-in or temporarily abandoned. Shut-in status should begin 90 days after operations stop, and temporarily abandoned status should commence after temporary abandonment operations have been completed (downhole lift equipment and tubing have been removed, and a bridge plug has been set). An inactive or temporarily abandoned well can be more easily put back in production than a permanently abandoned well.
Licence, licencing	A licence is an official document which gives you permission to do, use, or own something. For geothermal development, the licence (authorisation) grants the exclusive right, in accordance with the regulations of corresponding law, to explore and extract the resources specified in the permit and to co-extract resources in a specific field. The licence also clarifies the ownership.
Permanently abandoned (or liquidated, suspended, or decommissioned) well	A well is permanently closed off when no viable hydrocarbons are discovered or it is depleted and no longer capable of producing profitably. The well is permanently plugged downhole, producing subsurface formations have been isolated and permanently plugged, and the well has been permanently decommissioned. The wellhead is usually cut off and the land surface reclaimed.
Permit	The permit is the formal, written approval of an application issued by the regulator to perform work on a well. The permit grants the

	exclusive right to search for the mineral resources specified in the permit in accordance with the regulations in a particular field.
Reuse, repurpose	Repurposing is the process by which a well with one use is transformed or redeployed with an alternative use. In this case, hydrocarbon wells may be used for other purposes, e.g. water production or geothermal energy.
Workover	A workover is any operation done on, within, or through the wellbore after the initial completion. Although proper drilling, cementing, and completion practices minimize the need, virtually every well will need several workovers during its lifetime to satisfactorily fulfill its purpose. Workovers may be required for one or more of the following reasons: unsatisfactory production or injection rates, supplemental recovery project requirements, regulatory requirements, competitive drainage, reservoir data gathering, lease requirements, or abandonments. Workover can include artificial lift installation, acid stimulation, scale and paraffin removal, hydraulic fracturing, sand control, etc.
ATES	**Aquifer Thermal Energy Storage** In ATES, heat is stored in a subsurface aquifer when it is available in excess (usually summer), and it is retrieved when it is needed (winter). Crucial parameters for success are appropriate thermal conductivity and heat capacity, hydraulic conductivity, and storage capacity of the aquifer. ATES facilities can be used either in shallow unconfined or in deep confined aquifers. Deep confined aquifers are often preferred because the regional groundwater flow is usually low or negligible (which prevents loss of the hot stored water), the heat loss is reduced due to the depth, and the initial temperature regime is higher due to the natural geothermal gradient. ATES systems in shallow unconfined aquifers are less expensive for well installation and monitoring, but groundwater horizons must be protected from potential impacts of heat storage.
DBHE	**Deep Borehole Heat Exchanger** A Borehole Heat Exchanger (BHE) is a device to extract geothermal heat from rocks without production of water or other formation fluids. It is a heat exchanger installed inside a borehole, circulating heat-carrying fluid down and up. The fluid does not interact directly with the rocks or water in the borehole but is restricted to flow only inside pipes inside the borehole, so heat is transferred by conduction. BHE's can be shallow or deep. Deep Borehole Heat Exchangers (DBHE) can reach rocks of higher temperatures and thus can supply more energy than shallow BHEs. DBHEs are often installed in dry unsuccessful boreholes.

BTES	**Borehole Thermal Energy Storage** Similar to ATES systems, BTES installations store heat in the underground, but instead of open communication with the aquifer as in ATES, BTES systems store and retrieve heat to and from the subsurface by means of Borehole Heat Exchangers (BHEs). BTES is recommended for small to moderate energy needs where groundwater is scarce or hydrogeological conditions are unfavorable for pumping water. To avoid subsurface water movement and thus loss of the stored heat, groundwater flow should be minimal. The energy production capacity of BTES is lower than ATES but is compensated by easier design and installation. BTES arrays often contain many BHE's for scaling up the energy production.
EGS	**Enhanced Geothermal System** EGS can be used to describe any geothermal system that has been engineered by technological means to improve permeability or fluid mass flow. EGS is often used in settings where a well has been drilled and does not produce fluid as expected. Enhanced flow can be accomplished by creation of fractures in impermeable or low-permeability rock (through, for example, injection of water to pressurise the subsurface or selective dissolution of rock), thus allowing fluid to flow more freely and energy to be produced in areas where production was previously not possible or was not economical.
HE	**Hydrothermal Energy** HE is electricity or heat energy produced from hydrothermal heat, which is the thermal energy stored in hot water and steam within the Earth's crust, usually associated with volcanic activity or geothermally active areas. In a geothermal power plant, this heat can be converted into usable energy. In the case of electricity production (which, for HE, is more common than production of heat), hydrothermal heat is used to produce steam, which drives turbines connected to electricity generators.

Appendix 1 - Questionnaire Hungary

Author and country update on well reuse

Author	György Márton; Klára Bődi-Gábor Magyar; Judit Schäffer
Organisation	CROST Nonprofit Ltd. Co. and Mining Property Utilization Nonprofit Public Ltd.
Country	Hungary
Contact	schaffer@crost.hu; +3630/577-32-19

Executed projects: Do reuse projects exist in your country? If yes, please indicate the name, starting date, approximate duration of use, project partners and a short description.

In Hungary, the state-owned Mining Property Utilization Nonprofit Public Ltd. company is entrusted with reuse of state-owned hydrocarbon wells that were originally non-productive or that are no longer productive.

Several ongoing reuse projects have been running in Hungary since 2016 for example for district heating service, agricultural, balneological, electric power plant usage.

1. Do you have information about the procedure for reuse of wells and about lessons learned from practice? If so, please describe them.

The state-owned wells are transferred for utilization through public tenders. Based on the State Property Act the state-owned abandoned wells can be transferred for 15 + 5 years. The tenders are handled by the Mining Property Utilization Nonprofit Public Ltd.

2. Are there reuse projects in the planning phase? If yes, please indicate the name and a short description, if possible.

Several state-owned abandoned wells have been transferred for reutilization in different sectors. In these projects the wells are planned to be used for energetic purposes in the agricultural area for heating buildings, greenhouses and foil tents and there are plans to use certain wells for electricity production in the industry.

3. Is the reuse of wells a political topic in your country? E.g., do national, regional or local energy plans mention well reuse? Do companies/others show interest in well reuse?

The Hungarian Government aims to reduce the country's exposure to energy imports by replacing up to 1-1.5 billion cubic meters of natural gas per year by the end of the decade with the widest possible use of geothermal energy.
In 2020, 5.6% (2,772 TJ) of Hungary's thermal energy production was provided by geothermal energy, 0.03% of domestic gross electricity production, geothermal energy provided 11 GWh (Turai geothermal power plant), the primary renewable 4.8% (6,274 TJ) of the production of energy carriers and 5% of its primary use were provided by geothermal energy.
23% of domestic geothermal utilization is represented by geothermal district heating and thermal water district heating systems. Geothermal district heating is available in a total of 21 settlements out of the total of 94 district heating systems (Barcs, Bóly, Cserkeszőlő, Csongrád, Gárdony, Győr, Hódmezővásárhely,

Kistelek, Makó, Miskolc, Mórahalom, Nagyatád, Orosháza, Szarvas, Szeged, Szentes, Szentlőrinc, Szigetvár, Szolnok, Vasvár, Veresegyház) where thermal water partially replaces gas-based heating, depending on local conditions. Despite the 21 geothermal DH systems, the total share of produced geothermal heating energy out of the total DH heating energy is rather low, only 2.8%. The thermal water reaches the buildings to be heated through a pipe specially established for this purpose, which are typically public buildings: hospital, town hall, kindergarten, school, etc.
The largest domestic field of geothermal energy utilization is agriculture, with a share of about 40%. The heating of the greenhouses and foil tents is particularly outstanding in the area of the Southern Great Plain. Although not for direct energy purposes, the long-standing domestic thermal water spa culture (23% share) is definitely worth mentioning from a national economic point of view.

Companies interested in reuse:
Hungarian National Assets Management Co., Ltd.
Mining Property Utilization Nonprofit Public Ltd.

4. We are considering the reuse of wells as deep geothermal utilizations. Is there a depth defined in your country that marks the start for deep geothermal? Do you think the reuse of wells makes sense at shallower depth?

The depth at which geothermal energy is considered "deep" can vary from country to country and region to region (depends on the extent of the geothermal gradient). There isn't a universally agreed-upon depth marks the start of deep geothermal energy however the Hungarian Mining Law defines the wells with a reservoir temperature higher than 60 C are considered as deep geothermal wells in Hungary.
Yes, reuse of wells at shallower depths makes sense.
For example, the thermal energy of lower temperature (25-48 C) thermal waters can be raised to a temperature of 83 C with extremely high efficiency (SCOP=6) using special w-w heat pumps (best practice: Nagyatád geothermal waste heat utilisation system).

Data, well ownership and well condition

Data in this section concerns the knowledge about the existence of wells – availability, ownership, storage (how to find a well and its owner)

6. What industries are there in your country that use/need boreholes?

1. All industries i.e. car manufacturing, chemical industry, steel and iron manufacturing, toy factory etc.
Remark at workshop 2024:

- Oil and gas industry
- Agriculture
- Medical - Balneological
- Geothermal energy
- Food - Drinking Water, Botteling
- Mining
- Geological Research (Research Drilling)

7. How many of these companies are operating in your country (please separate between the industries, if applicable)? How many wells are there in your country (give only an estimate)?

Car manufacturing companies (Audi-Mercedes-BMW), chemical industry companies (Procter and Gamble-Unilever), steel and iron manufacturing company (Dunaferr), toy factory company (LEGO) etc.

Hungary is an exceptionally well-researched area from the point of view of geothermal energy: thanks to nearly 9,000 hydrocarbon wells and deep drilling wells for other purposes which deeper than 500 m exceeding more than 10,000, the nearly 1,700 hot water geothermal wells, the 3D seismic data blocks covering 22% of the country and the approx. 6700 pieces of 2D reflection log profiles, as well as a large number of other geophysical measurements.

8. If applicable: For these industries, are there any legal differences between the drilling of a well and the use of a well?

   Are special permits necessary (please indicate the legal basis)? Does this affect the reuse of a well? Please explain if yes.

A uniform system of rules applies to all industries and any kind of applications based on:

- Mining Law- XLVIII of 1993 law about mining

XLVIII of 1993 on mining. Act (hereinafter: Bt.) effective from 01.03.2023 § 5 (1) point g) the Mining Supervision Authority authorizes the research, extraction and utilization of geothermal energy through the extraction of thermal water, with the exception of the extraction of thermal water for primarily medicinal or primarily agricultural purposes . Bt. 21/A. Pursuant to paragraph (1) of § §, geothermal energy research can be carried out based on the permission of the Mining Supervision Authority.

9. Is there publicly-available data on existing wells? What information does this data include (e.g., owner, production status, depth, age)? Please also explain if this database is complete for your country (are all existing wells in this database) and if there are differences between the different industries.

The voluminous geological-geophysical-hydrogeological knowledge material is stored in modern digital databases, the GeoBank is worth mentioning, which contains the data of nearly 270,000 shallow and deep boreholes drilled in Hungary. In addition, the unique geological collection consisting of more than 500,000 mineral, rock, and fossil items forms an outstanding part of the data assets; The largest Geological and Geophysical Library of Hungary, consisting of more than 300,000 units; as well as a core sample collection containing the core material of about 8,100 deep boreholes drilled in the territory of the country.
This GeoBank database includes all relevant information from the wells.
There are no differences between the different industries.

10. Is there any information publicly available about the well conditions - is it still open, permanently or temporarily abandoned? Are there data available on the abandonment works? If yes, how can they be accessed?

Yes, there is information publicly available at SARA (Supervisory Authority of Regulatory Affairs) Directorate of Geology from GeoBank and at Mining Property Utilization Nonprofit Public Ltd. from their databases.

11. Must the existence and status of a well be reported? If so, to whom?

The drilling of wells deeper than 150 m requires a permit and the data/status of well must be reported to SARA (Supervisory Authority of Regulatory Affairs) Directorate of Geology into the GeoBank.

12. Who owns a well and its equipment? Is it the person who drilled the well, the state or someone else? (Please separate between the industries if applicable)

The owner of the well and its equipment is the permit holder who received the permit for drilling, and can only be a legal person. A condition for a drilling permit is the acquisition of exploration or concession rights for a given geographical area.

13. Is the land where surface facilities are placed mostly leased or company-owned?

A condition for a drilling permit is the acquisition of exploration or concession rights for a given geographical area.

14. Are there regulations on how to manage wells that are not used for the intended purpose or are no longer used? If so, what is the legal basis for this?

Completion of the drilling activity, abandonment and liquidation of the wells (1) After the drilling is completed, the well must be fenced off and the extent of the safety zone – appropriate to the nature of the well – and the border of the explosive zone must be marked with a sign. (2) The mining contractor shall ensure that the drilled well is maintained in a safe condition and that unauthorized persons are physically prevented from interfering with it. (3) The safekeeping and regular inspection of a temporarily abandoned, non-operating well must be carried out and documented on the basis of a plan approved by the mining contractor. (4) It is included in the liquidation plan a) the reason for liquidation, b) characteristic data of the sheared hydrocarbon storage layers, c) the characteristic data of layers that can be used for other purposes, d) the data and condition characteristics of the lining pipe columns and cement casings, e) the length of the planned cement plug(s) and the method of the closure test, as well as f) the type and density of the fluid filling the well. (5) Liquidation must be carried out in such a way that between the pipes of the lining pipe columns no open layer section containing hydrocarbons should remain. (6) The permanently abandoned well must be closed with a cap equipped with a needle valve at least 1 m below ground level. (7) It must be ensured that the liquidated well can be identified.

15. What is the common timeframe for well abandonment since production stop?

It varies a lot, it can be up to 30-50 years from immediate well abandonment. Common timeframe is around 20 years. Email from Klara Borodi 18.3.2024 The point is that in Hungary according to the mining law, all well owners are obliged to carry out a risk assessment for the abandoned wells. The abandoned wells are divided in 4 categories (very high, high, low high, non-risky) based on technical issues. If a well is classified as very high or high, it is recommended to carry out well works that can reduce the risk classification of the well to a low category. Only very high and

high risk well must be closed technically. Low and non-risky wells do not currently have to be closed according to the mining law. Technical closure means that the lining pipe is cut at the depth of 1,2 meters, in 90% of cases the smallest diameter tube is partially removed and the well is closed safely with cement plug(s) and a steel cap.

16. Are there technical requirements (standards) for the abandonment procedure? Are they legally binding?

Based on the asset management contract concluded with the Hungarian National Asset Management Co. Ltd. and the current legislation, the hydrocarbon business is responsible for the proper asset management of state-owned deep wells for mining purposes, protecting their condition and condition, fulfilling the landscape planning obligation related to deep wells, and utilizing the deep wells.

17. According to the law, how long can a well be kept shut-in or temporarily abandoned without production? What is needed (e.g., field development plan if other drilling locations are planned, production licence, etc.)?

Based on the mining law, the use of the well can be suspended for an indefinite period of time, but the owner of the well must liquidate the well sooner or later. It's always an economic issue.

18. Are there obligations to consider (immediate) reuse of a well, if a project was not successful in terms of its planned purpose?

No.

19. Do you know if orphan wells exist in your country? How do you get this information?

As our knowledge there is no orphan well exist in Hungary.

Data, possible uses and utilization

Data in this section concern information available to define the usability of a well (geology, hydrogeology, reservoir details…)

20. Are there requirements to report drilling plans and well data after drilling to authorities in general? If yes, which information/data has to be provided?

Drilling report - Implementation documentation

The mining contractor shall operate a documentation system on the drillings carried out, the wells drilled, and the well work carried out. The documentation of the well includes:

- the execution diary (daily report)
- data on the structure of the well,
- the diameter, length and material grade of the casing and tubing ,
- the data of the cement bond,
- concerning the location of open sections, perforations and cement plugs in the well information,
- the data of the installed production equipment,
- the pressure limit and type of the wellhead assembly, as well as
- certificates of conformity of the installed materials and fittings.

The documentation of the well must be preserved until the end of the mining activity.

21. Is this data or parts of it publicly available for free or at least partly free?

Basic data is freely available and detailed data can be purchased through the one-stop system.

22. Who is the data owner of raw data (well data, log data, etc.)?

The mining contractor and state-owned SARA (Supervisory Authority of Regulatory Affairs) Directorate of Geology

23. Who is the data owner of data interpretations (based on the well data or seismic data)?

The data interpreter.

24. What is the attitude of companies/authorities regarding providing data from wells or making well data available to the public? Do you have any experience with this?

Basic data is freely available and detailed data can be purchased through the one-stop system.

25. Where are well databases stored (at commercial companies, administrative organisations, authorities, universities and/or others as e.g., web maps, web services, etc.)? Please list them with references.

Well databases stored at state-owned SARA (Supervisory Authority of Regulatory Affairs) Directorate of Geology in GeoBank.

26. List categories of well data which are freely available for the public (at commercial companies, administrative organisations, authorities, universities and/or others as e.g., web maps, web services, etc.).

Basic well databases which are stored at state-owned SARA (Supervisory Authority of Regulatory Affairs) Directorate of Geology in GeoBank and OGRE (National Geothermal Register) system: https://map.mbfsz.gov.hu/ogre_en/

27. Estimate and describe in which formats most of the data is available. Is the data in digital formats, or is it scanned, in paper format or in another format (e.g., microfilm?).

Most of the data is available in digital format but few of them in scanned and paper format.

28. Who is responsible for well integrity before establishing the recompletion for reuse?

The mining contractor.

29. How can the ownership of a well be changed? Is it a simple contract between two parties or are there legal obligations to consider?

In case of the state-owned wells the change of the ownership of a well is regulated by the State Property Act.

30. What are the requirements for the new owner/leasing operator (e.g., proof of capital)? Is a well owner change related to a change of production licences?

The requirements are totally the same for the new owner/leasing operator.

31. Are obligations transferable to another owner/operator? If yes, is it a common procedure?

Rights and obligations together can be transferred only to the new owner not for another i.e. 3rd party operator.

32. Are well integrity tests required before and/or after recompletion (e.g., special surface equipment for possible hydrocarbon leakage, etc.)?

Yes well integrity tests are required before and/or after recompletion.

Legal framework, licence/administration

This section focuses on regulatory approval for well reuse. At this point, it should already be clear how the well will be used and what measures will be required (e.g., installation of tubing, drilling side tracks, extending the depth, production tests, etc.…).

33. Resource – Does your country consider geothermal heat as a raw material? If yes, what is the legal basis?

XLVIII of 1993 on mining. According to Section 3 (1) of the Act (hereinafter: Bt.), mineral raw materials and geothermal energy are state property in their natural places of occurrence. The mineral raw material extracted by the mining contractor becomes the property of the mining contractor upon extraction, and the geothermal energy extracted for energy purposes upon utilization. Paragraph (1) of § 20 of the Bt. stipulates that the state is entitled to a share and mining royalty after the extracted mineral raw materials and geothermal energy.

34. Who owns the resource? Down to which depth?

Drilling wells deeper than 150 m the resource is owned by Hungarian state.

35. Do you need an extra permit for workover? How is a recompletion handled? Is it different if the owner and the purpose of use change?

Basically, no permit is required for workover operations but must be notified to the mining authority 30 days before the start of the activity. Yes, the procedure is different if the owner is different, the well must be handed over to the new owner and the well must be reclassified.

36. Please, briefly explain the legal basis for the approval of geothermal systems in general in your country. Consider the different application forms for geothermal energy (e.g., deep BHE, pumping/reinjection well for HE, etc.). Which legal instruments apply and are they valid for a reuse? At which legislative levels are these regulations valid and executed (national level, regional

level, local level)? Is the process comparable to that for a reuse? Please note differences between the reuse methods.

The one-stop system, which will enter into force on March 1, 2023, creates an efficient and fast administration. Extraction and utilization of geothermal energy can be done on the basis of a contract with the Mining Supervision Authority.
The new licence form provides sufficient flexibility and a predictable legal framework for both the mining entrepreneur and the state. Through the contract, the state can control the activities of the mining contractor and can intervene if necessary. Long-term sustainable investments can be realized thanks to the new legislative environment.
Based on the new regulations, the process diagram of authorization can be seen below:

Research

- Application for research permit
- Research work program
- Decision authorizing geothermal research

Final report-Protection zone

- Final research report
- Request for appointment of protection zone
- Decision establishing a geothermal protection system

Usage contract

- Application for the conclusion of a geothermal energy extraction and utilization contract

In addition to the mining supervision acting as the authority, the Geothermal Energy Commission (GEC) also participates in the licence procedure for geothermal energy research as a professional advisory body, which consists of delegates from all members of the Government with responsibilities related to the research, extraction and utilization of geothermal energy.
In addition to a detailed description and schedule of the research tasks, the research work program must include the expected thermal water demand related to the planned geothermal energy utilization (by specifying the temperature and yield), as well as an analysis of the possibility of its extraction in order to assess the project's preparedness and professional soundness.
The condition of concluding the contract is that the geothermal protection period has been designated. In addition, a declaration of rights or intent to utilize heat is required, as well as a commitment to extract the annual amount of heat planned to be utilized.
The utilization contract includes the purpose of geothermal energy extraction, the form of utilization and the extraction technology, as well as provisions related to back-pressing.
The extraction contract can be concluded for a maximum of 35 years, which can be extended once, at most by half of the original period. As a result of the change in legislation, the regulation regarding the geothermal concession limit tied to a depth of 2,500 m has lapsed.

Coordination of research areas
If several requests apply to the same area or part of the space (i.e. they overlap), the mine supervision invites the applicants to a consultation, the purpose of which is for the applicants to modify their research areas based on consensus. If the negotiation is unsuccessful, the mine supervision decides on the delimitation of the research areas.
If the research area concerns mining sites established for the extraction of crude oil, natural gas and carbon dioxide gas or underground gas storage, or the research area of crude oil, natural gas and carbon dioxide

gas, the applicant must obtain a statement from the authorized person regarding the research, which is a condition it can be consent without consent, or conditional consent or refusal with reasons.

Research blocks
The research area must be established in blocks. The area of a research block can be the size necessary to carry out the research activity, but no more than 100 km2 in the case of research up to 1000 meters from the natural surface, 200 km2 in the case of research between 1000 and 2000 meters from the natural surface, and 400 in the case of research below 2000 meters from the natural surface. km2. A mining entrepreneur and his affiliates may hold exploration permits for up to eight exploration blocks at the same time.

Research facilities
A relevant aspect in relation to structures for geothermal energy research (deep drilling) is that if the archival data necessary to determine the geothermal protection zone is available, then the construction of a research facility is sufficient, no other research tasks need to be carried out. At the same time, it is possible to conduct research using existing mining facilities without a new research facility, if the applicant has the right to use them and the facility is also suitable for extracting geothermal energy.

Final research report
The content of the final research report is determined by the annex to the SZTFH decree. The final report must contain all relevant data required to determine the geothermal protection period. There is no separate procedure for the acceptance of the final report. It must be submitted even if the mining contractor does not request the determination of the geothermal protection period.

Protection zone
The mining contractor will make a proposal for the geothermal protection zone based on the data and information provided in the accepted research final report and in the application. The designated geothermal protection zone ensures the geological and, with it, legal limits for the extraction of geothermal energy.
Since this legal protection also means investment protection, the most "risky" phase of geothermal energy investments so far has been protected. All of this is expected to have a positive effect on the size and quality of geothermal investments.

Research activity
On the basis of the research permit, the mining contractor is exclusively entitled to carry out instrumental measurements, tests, and drilling to determine the conditions of geothermal energy in the earth's crust in the research area, as well as to initiate the designation of the geothermal protection zone.
The research period is a maximum of 4 years, which can be extended once by half of the authorized period. The decision authorizing the research also includes the duration of the execution of each research task.

Reinjection
Based on the current legislation, groundwater may only be used to the extent that the balance between water extraction and water supply is maintained without quality damage.
In Hungary, the mining contractor must fully reinject the extracted water according to the technical and geological possibilities.
The Hungarian law, which still does not make the reinjection compulsory, intends to have an encouraging effect on investors regarding the construction of the reinjection system.

Financial security

The new regulations also provide for financial guarantees, the primary purpose of which is to exclude applicants with unreliable financial and professional backgrounds. The financial guarantee is also used to settle expected damages in connection with the research, to fulfill environmental and nature protection, landscape planning and mine damage obligations. Its minimum amount can vary between HUF 40-200 million, but it is adjusted to the obligations of the mining contractor.

Cascade systems
The new regulatory environment also tries to include the energetic side of geothermal energy utilization in the regulation.
The legislation encourages for the sake of the greatest usable energy, regulates responsible energy utilization and the creation of cascade systems by making undertakings mandatory.

37. What exactly needs to be approved for geothermal energy plants - the installation of the equipment and/or the energy generation? For example, is it the use of heat, the use of water, or the influence to the environment/water?

See answer in point 36.

38. Is there a difference in the licensing if you will produce heat or power?

No, pls. see answer in point 36.

39. Are there different regulations for different depth levels?

Drilling wells deeper than 150 m requires a permit in Hungary.
The permit for geothermal drilling for agricultural and spa purposes is issued by the regional water authorities. In these cases, there is no obligation for users to reinject the water back into the reservoir.

40. Is there a difference in permitting related to the different possibilities of reuse?

No, the permitting regulation is the same to the different possibilities of reuse.

41. Are there legal requirements for monitoring?

Yes, monitoring is required for some activities, for example seismic monitoring wells must be drilled for the EGS system or monitoring system is required for CO2 storage.

42. If testing is needed, what kind of permits or working plans are needed?

The permitting system is the same as by default. Pls. see answer in point 31.

43. What is the permitting procedure to drill a side-track or to expand the depth of an existing well? What are the legal requirements?

The permitting procedure is the same as by default. Pls. see answer in point 36.

44. Are there specific environmental regulations in place for well reuse, and if so, what are they? Is there an obligation for an environmental impact analysis?

Yes, the authority can require the preparation of an environmental impact study in environmentally sensitive areas.

45. Do you know any reasons why a reuse or the recompletion is forbidden (e.g., region was repurposed as an environmental protection zone, etc.)?

Environmental protection zone (Natura 2000)

46. Which entities are involved in the licensing procedure?

For the conclusion of the concession contracts, the XVI of 1991 on the concession a minister or a central government administrative body designated in a government decree pursuant to § 5, subsection (1) of the Act calls for a public tender.

47. Who is the authority to supervise the repurposing process of abandoned wells?

SARA Mining Supervision Authority.

48. Is there a One-stop shop system for application (one responsible authority for the execution of a licensing procedure)?

Yes there is an one-stop shop system, which was entered into force on March 1, 2023, creates an efficient and fast administration. Extraction and utilization of geothermal energy can be done on the basis of a contract with the Mining Supervision Authority.

49. Is an online application possible?

Only online application is possible through a one-stop shop system.

50. How long does a permission procedure take? Are there maximum time limits for procedures? Is there automatic permission after a deadline passed?

A permission procedure takes appr. 3-6 months. Yes there are maximum time limits for procedure. There is no automatic permission after a deadline passed!

51. How long is a permit valid?

According to the amended mining law for geothermal production (except for balneology and agriculture) a geothermal research permit must first be obtained, this permit is valid for maximum 4 years and can be extended for another 2 years. The duration of the extraction concession is 35 years from the date of entry into force of the contract.

52. Is the permission related to special obligations during the installation and operation (e.g., reporting of production data, etc.)?

- Definitely yes.
- Final research report
- The content of the final research report is determined by the annex to the SARA (Supervisory Authority of Regulatory Affairs) decree. The final report must contain all relevant data required to determine the

geothermal protection zone. There is no separate procedure for the acceptance of the final report. It must be submitted even if the mining contractor does not request the determination of the geothermal protection zone.

Part 2 – Financial framework

The purpose of this questionnaire is to provide an overview of the financial framework for geothermal applications for reuse of existing wells.

Please note that reuse may require additional infrastructure compared to a conventional geothermal project because reuse is tied to existing sites. This means that heat exchangers or pipelines will be required to mitigate the reduced heat output.

Financial framework and funding

National funding

53. Is there national funding for geothermal applications based on reuse of existing wells? List the funding available.

If yes, please name it, give a reference, purpose, and amount. Who is eligible for a given programme or funding source?

If not, are there suitable alternative funding schemes, which can be used for this purpose?

To date, government support policies have focused on the deployment of solar PV. Large potential for scaling up renewable energy remains, for instance in geothermal energy or wind power. The government has plans to mobilise funding and implement derisking mechanisms for geothermal in the coming years.

There is currently no national funding available in Hungary for geothermal applications based on reuse of existing wells, but it is expected that there will be in the near future (SWISS- HUNGARIAN COOPERATION PROGRAMME Period II, Thematic area Energy efficiency and renewable energy sources, Programme SM06-GEO "Geothermal energy sources for district and urban heating").

54. Which are the typical timeframes for funding? Which types of the project they are covering (e.g. feasiblility process, installation, operational phase).

What are the requirements for funding?

Which are the typical timeframes for funding?

For completed and expected tenders, there is a maximum of 36 months for the implementation of the tender.

Which types of the project they are covering (e.g. feasiblility process, installation, operational phase).

Funding is available primarily for the installation and operational phases.

The supported activities under the already closed assistance were aimed at creating new geothermal capacity or expanding existing capacity.

The following activities are expected to be eligible under the programme SM06-GEO "Geothermal energy sources for district and urban heating":

1. Upgrading, rehabilitation and conversion of existing active or closed, producing or recovering thermal wells with geothermal potential, but which are not in use at the time of this call for proposals, into publicly owned barren hydrocarbon wells to increase sustainable geothermal energy production.

2. Increasing the capacity of production and recovery wells for geothermal energy production by carrying out other upgrading and well engineering works;

3. Bringing closed thermal, thermal or barren hydrocarbon wells into geothermal thermal production by refurbishment or conversion.

What are the requirements for funding?

For the closed funding scheme (project):

Only organisations established in Hungary or in the European Economic Area and with a branch in Hungary may apply for funding under this call for proposals.

The economic condition for eligibility:

(a) The average statistical headcount of the applicant, as shown in its published annual accounts for the last full financial year for which it has been closed and which is complete (365 days), must not be less than 1 person.

(b) The applicant's equity capital, as shown in its published annual accounts for the last full financial year for which the accounts have been closed and for which there are no more than 365 days of activity, must not be negative

For the expected funding scheme (project):

Economic eligibility criteria

The following criteria must be assessed separately for each company and must be met.

1) The published annual accounts of the applicant for the last full (365 days) financial year for which the accounts have been closed

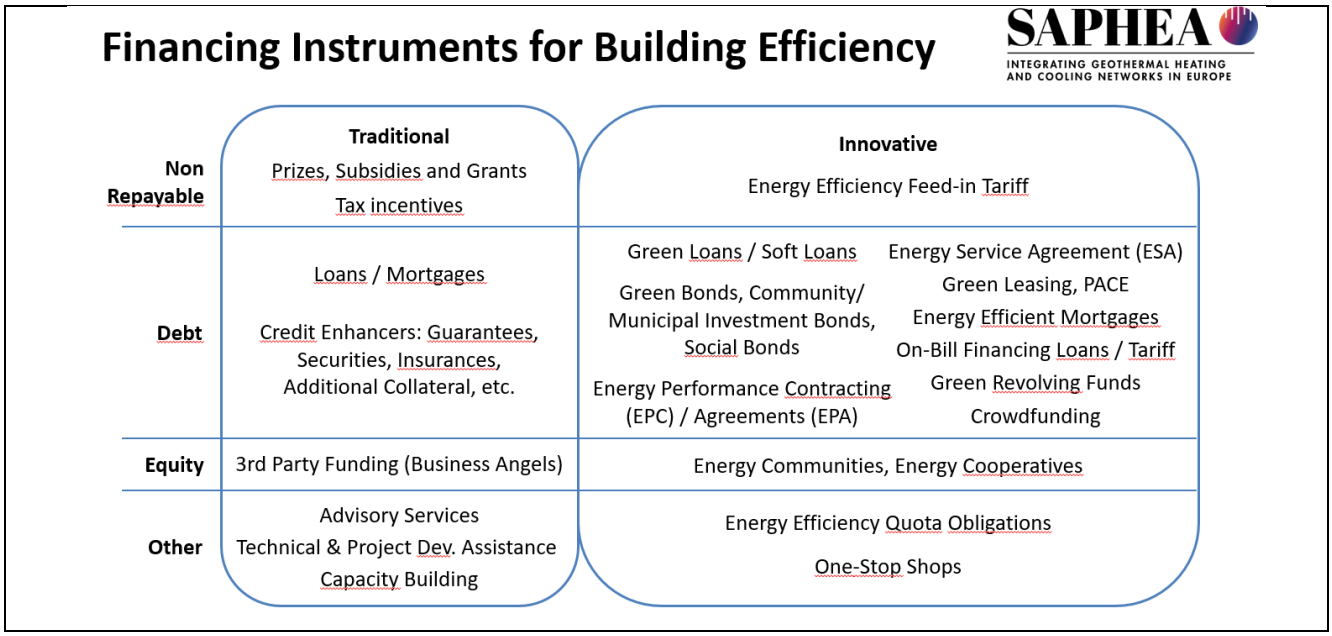
The average statistical headcount of the applicant must not be less than 1 person.

2) The published annual accounts of the applicant for the last full financial year for which the accounts have been closed (365 days)

The applicant's equity capital as shown in the published accounts of the applicant's last published financial year.

Traditional and innovative financing options

55. Are there examples of financing options in your country listed in the Figure below? If so, please name and describe them.



56. Are there any other financing options in your country or do you know about any other in general (e.g. can be an example from another country)?

The most important energy efficiency measures were non- or partly refundable support schemes, outlined in the Operational Programmes (OPs), financed by EU Funds. The focus of the 5th priority axis of the Environmental and Energy Efficiency Operative Programme (KEHOP) was explicitly the improvement of energy efficiency, combined with the development of renewable energy solutions in public buildings, the development of heating systems, including district heating, and awareness raising. The TOP programme financed energy efficiency upgrades at local authorities. The GINOP programme had also sub-programmes that aim to promote energy efficiency in the enterprise sector and also financed a residential zero interest loan scheme operated by state-owned Hungarian Development Bank. The various Operational Programmes target a wide range of consumer groups, with potentially supportable projects, related to energy efficiency improvement in buildings, to industrial production and processes, and renewable energy.

https://www.odyssee-mure.eu/publications/efficiency-trends-policies-profiles/hungary.html

· Project Selections for FOA 2799: Regional Initiative to Accelerate Carbon Management Deployment: Technical Assistance for Large Scale Storage Facilities and Regional Carbon Management Hubs

https://www.energy.gov/fecm/project-selections-foa-2799-regional-initiative-accelerate-carbon-management-deployment

· EEA grants and Norway Grants secured funds

Dravske Elektrarne Maribor (DEM) received EUR 730,000 in April under a public call for the co-financing of a climate change mitigation and adaptation program. ***It is financed by the European Economic Area (EEA)***

Financial Mechanism and the Norwegian Financial Mechanism. Slovenian companies. DEM, Petrol, and Nafta Lendava have made an important step toward implementing their business endeavor – the first pilot geothermal power plant in Slovenia with the use of innovative technology. The country currently doesn't have any geothermal power plants. In February 2021, DEM, Petrol, and Nafta Lendava signed a letter of intent to implement the project, which envisages the exploitation of geothermal energy from abandoned gas and oil wells. The pilot project will use the geothermal energy potential of an existing dry, unproductive well. The research-pilot project in the community of Čentiba will use the geothermal energy potential of the existing dry, unproductive 3,000-meter deep well. The project will use a geothermal gravity heat pipe, a technology patented in Slovenia (SI 23618 A). It will be the first application of a Slovenian patent that DEM has the right to use. It can lead to a breakthrough in using geothermal energy in deserted gas and oil wells.

https://balkangreenenergynews.com/three-slovenian-companies-develop-geothermal-facility-on-abandoned-oil-gas-well/

Other incentives

57. Are there any financial incentives for companies to locate in regions where abandoned wells are situated? If yes, please give a short description.

The place where the investment will be made matters, not the location of the company.

The aid intensity may be increased by 20 percentage points for aid granted to small enterprises, and by 10 percentage points for aid granted to medium-sized enterprises in the regions of Northern Hungary, Northern Great Plain, Southern Great Plain, Southern Transdanubia, Central Transdanubia and Western Transdanubia.

58. Does development or strategic planning for regions with abandoned wells exist?

- The government aims to install at least 400 MW of heat pumps in 100 000 systems by 2030. In addition, the National Energy Strategy 2030 also supports the development of electricity-based heating in regions where the use of the gas distribution networks is below average, and in areas where no access to the gas distribution grid is available.

Switching from the use of natural gas to the use of renewable sources in the district heating system is another government priority. The goal is to reduce the share of natural gas consumption in district heating production to 50% under the Green District Heating Programme.

- Hungary is committed to increase the share of renewables in heating and cooling to 30% by 2030. Biomass is important in the short to medium term, but in the long run priority is given to heat pumps and other electric heating solutions, due to the limited availability of sustainable biomass. In addition, the National Energy Strategy 2030 also supports the development of electricity-based heating in regions where the use of the gas distribution network is below average, and in areas where no access to the gas distribution grid is available. District heating is one good option for decarbonising the heating and cooling sector. The potential for geothermal energy is of particular interest for Hungary and is significant (estimated at 30-65 PJ/year), but

progress has been slow and there are no targets. However, the government is setting up the Geothermal Guarantee Fund and the Green District Heating Programme. The IEA encourages the government to promote all efforts to reach the targets of the Green District Heating Programme (defined by the NECP) and to establish the Geothermal Guarantee Fund (as planned under National Energy Strategy 2030). International experience shows that geothermal energy requires a range of specific framework conditions to spur investment. The use of heat pumps is another technology option under the long-term strategy for switching away from fossil energy in heating and cooling. The National Energy Strategy 2030 has a goal of at least 400 MW of heat pump capacity with 100 000 systems (up from 148 MW in 2019). Compared to the potential, this is a modest target and development can be ramped up. If the regulated price for gas were to be removed, this ramp up could probably be achieved without economic support for those households that are not "energy poor". Increased prices for natural gas and information and marketing campaigns would help this market take off. https://iea.blob.core.windows.net/assets/9f137e48-13e4-4aab-b13a-dcc90adf7e38/Hungary2022.pdf

- In 2021, FŐTÁV signed a co-operation agreement with the Icelandic group Artic Green Energy for the construction of geothermal heat plants to provide heat for the city network. The initial project aims to build 10-20 megawatt thermal (MWth) of heat generation capacity. The first substantive phase of the project includes exploration of potential locations, obtaining the necessary permits and technical preparations. In the long run, the company aims to achieve 150-200 MWth of heat generation from geothermal wells, as well as increase heat generation from waste.

- The potential use of geothermal resources for District Heating should be further explored and policies and measures adopted to support heating for residential or industrial uses, using the very good geothermal potential in Hungary. To overcome the barrier of high risk of investment for geothermal projects, the government could use policy tools such as guarantee and insurance schemes that have shown positive results in other IEA member countries.

Policies and measures in heating and cooling Hungary does not offer any specific support for combined heat and power; however, the government is considering introducing this in the future with support for heat storage, integration with battery energy storage devices and other emerging technologies. Various financial support schemes are available to homeowners and property developers who consider installing renewable heating technologies such as solar and heat pumps, as well as for the use of geothermal energy under certain conditions. The number of geothermal-based district heating systems almost doubled in Hungary between 2014 and 2018, but from a very low base and the untapped potential is still important. Since 2014, Hungary benefits from the EU-supported project GeoDH.eu, which provides a guide for the deployment of geothermal DH, along with a detailed map - http://geodh.eu/geodh-map/ - of the subsurface potential, combined with existing DH networks. The government estimates that the potential for deep geothermal to contribute to district heating is between 30 PJ and 65 PJ per year, which is notable considering the current use of about 9.3 PJ per year. The resource risk, linked with the uncertainties of the subsurface, is usually a major obstacle to the deployment of geothermal installations. The Mining Law Act and Act of Water Management do not have any particular provisions enabling or clarifying the rules for geothermal energy (notably using hot water springs) and new calls for tender and local concessions for harnessing geothermal energy have stagnated in recent years. Other European countries have developed various derisking policy

instruments, such as loan guarantees, grants or risk insurance funds, to provide support to geothermal projects. For example, the Netherlands increased its use of geothermal energy from almost zero to about 30 PJ per year from 2007 to 2017. A policy toolbox including an operating grant and post-damage guarantee, including collaboration with insurance companies, has supported the geothermal boom in the Netherlands.

Appendix 2 - Questionnaire Slovenia

Author and country update on well reuse

Author	Matej Prkič
Organisation	LEA - Pomurje
Country	Slovenija
Contact	Matej Prkic, matej@lea-pomurje.si

Executed projects: Do reuse projects exist in your country? If yes, please indicate the name, starting date, approximate duration of use, project partners and a short description.

There are 2 projects of reused wells still in operation. First location is in Moravske Toplice, well Mt-1 – research well for oil and gas. After the research performed in 1960 there were no big results, but they found thermal water. To use the well for other purposes they did a workover and completed the well for producing geothermal water for several decades. The well is still running today. Second location is Terme Lendava, they bought and produce geothermal water from two oil wells which undergone workover and completion in 2000 to 2007, for geothermal production Pt-20 an Pt-74. At least one is still in production.

Workshop comments: 2 HE, 1 DBHE

1. Do you have information about the procedure for reuse of wells and about learnings from practice? If so, please describe them.

The procedures were following.

- Get ownership of well and land, because the wells were drilled and completed by national oil and gas company.
- After getting ownership there was a procedure to get the concession for use
    - Filing applications for ownership, flow tests, volumes claim, …
- After getting the concession for use the production could start.
    - Production, reporting, maintenance,…
- 2 options for getting the concession licence.
    - Water act – all the water produced is dumped on the surface, if reinjection is in place there are some costs lowering options for the yearly concession fee. All systems of geothermal use in Slovenia.
    - Mining act – all water must be injected to the underground after usage. In Slovenia we have 1 such system.

2. Are there reuse projects in the planning phase? If yes, please indicate the name and maybe a short description.

One project undergoing in Moravske Toplice, the Municipality has ownership over one abandonment well Mt-2, which was tested in 2020 and 2021 and a concession for use was granted by the state for use.

On trial project in 2012/2013 to use one abandoned well for injection the geothermal water after use. Unfortunately, the project failed because of various reasons:

- Contact with the aquifer over perforations (oil and gas technique for connection with the target layer).
- No water cleaning before injection.
- Send production from the producing well and sand injection to the injection well.
- Other.

3. Is the reuse of wells a political topic in your country? E.g., do national, regional or local energy plans mention well reuse? Do companies/others show interest in well reuse?

No, it is not a political topic in our country. The awareness is quite low, and communities don't see the potential in those objects, or they even don't know they exist.

Some companies saw/see the potential but often getting the licences or ownership of the well and land they stop because of legislation which is forbidding new geothermal water use without injection. Because of leak of complete projects with real data of performance the interest is low.

Maybe with representing other options of use and other technologies there is room for encouragement for Municipalities and Companies to start such projects.

4. We are considering the reuse of wells as deep geothermal utilizations. Is there a depth defined in your country that marks the start for deep geothermal? Do you think the reuse of wells makes sense at shallower depth?

We have legislation wise one margin which is 300 m. Till 300 m everything is covered with the Construction act and Water act. Below 300 m the Mining act is in force, with in the Maning act no margins ate set. We just generally know that the low temperatures up to 80°C are expected til 2000 m and above 2.000 m temperatures 80°C and more.

Data, well ownership and well condition

Data in this sections concern the knowledge about the existence of wells – Availability, ownership, storage (How to find a well and its owner)

5. What industries are there in your country that use/need boreholes?

District heating – 1 facility
Thermal spa and Hotels – 10^{+} facilities
Grean House – 3 facilities

6. How many of these companies are operating in your country (Please separate between the industries if applicable)? How many wells are there in your country (give only an estimate)?

Rough – 20 companies

The number of geothermal wells in use – cca 30 pcs The number of geothermal well not in use – 15 pcs Abandoned Exploration wells for oil and gas – cca 100 pcs Production wells for oil and gas – cca 30 pcs Abandoned oil and gas wells – cca 160 pcs

7. If applicable: Are there any legal differences between these industries concerning the drilling of a well and the use of a well?
   Are there special permits necessary (please indicate the legal base)? Does this affect the reuse of a well? Please explain if yes.

We have 2 options: - Minig Act: Research licence for a bigger area for exploration drilling and other underground research. An area is open for research and you get some restrictions and guidelines where you are able to do research without limitations and where limitations need to be followed. - Water Act: Research of underground waters, you can drill wherever you want whit exceptions regarding protected areas and flood zones. The problem of changing the land purpose use comes afterwards and can take few years to get the official building permit.

8. Is there publicly available data on existing wells and what information does this data include (e.g. owner, production status, depth, age)? Please also explain if this data-base is complete for your country (are all wells that exists in this data-base) and if there are differences between the different industries if applicable.

The public data base is in progress to be available. One part of the data base is done the other part shall follow until Maj/June 2024. Some public data is accessible on Atlas okolja (gov.si)

9. Is there any information publicly available about the well conditions - is it still open, permanently or temporarily abandoned? Are there data available on the abandonment works? If yes have, how can they be accessible?

The data is in the company Petrol Geo, which is partly government owned. The data can be accessed for a certain fee, or they prepare a report for a particular location and collect the available data for the requested party.

10. Must the existence and status of a well be reported? If so, to whom?

For the wells in production a report is mandatory, and a yearly report is submitted by the users towards the authorized authorities. In case a status is changed reporting in obligatory.
The reporting is done to the Ministries and authorized bodies inside them. For example:
- Ministry of natural resources and space
  ○ ARSO – Environmental Agency of Slovenia
  ○ Directorate for waters
  ○ Mining department

11. Who owns a well and its equipment? Is it the person who drilled the well, the state or someone else? (Please separate between the industries if applicable)

The ownership of the well is from the investor who financed the drilling. There are some abandonment wells which are either on private or state-owned land and have no status of ownership.

12. Is the land, where surface facilities are placed mostly leased or company-owned?

The land is usually leased in the research phase whit prebuy option. Mostly the investors by land up front after they check the possibility on converting the land purpose and underground source existence.

13. Are there regulations on how to deal with wells that are not used for the intended purpose or are no longer used? If so, what is the legal basis for this?

There is no such regulation existing, nevertheless there are some locations left behind and without supervision nor dedicated authority to supervise. Usually until noting happens it´s from nobody.

14. What is the common timeframe for well abandonment since production stop?

By legislation you should do it immediately after you stop production, your concession is expired or taken away because unfulfilling the agreed scope of work. Reality, never because the owners or investors in case of unsuccessful intervention declare bankruptcy / close the company / sell the company. And the abandonment cost is pushed toward the State, or it is left to state to manage it. Several years ago there was started a collection of founds for abandonment, which is a way have to collect money from users in the production phase to have the resources or abandonment in case the manager company uses one of the listed options to overhand the cost and leaves.

15. Is there any procedure the abandonment is tackled today?

Yes, there is a fee each user needs to pay in the EkoSklad – Fund supervisor for collected abandonment fee from producers.

16. How long can a well at least be kept shut-in or temporarily abandoned without production from legislative side? What does it need for (e.g. field development plan if other drilling locations are planned, production licence)?

There is no such legislation in place to regulate this. The only was for the state is a lawsuit, which can last for years and even the state wins it there is nobody and nothing left to collect the needed founds for execution of abandonment of wells.

17. Are there obligations to integrate (immediate) reuse of a well, if a project was not successful in terms of its planned purpose?

There is an obligation by the Mining Project for drilling, from 2014 new rule book for Maning Project design is in place. Accordingly, the cost for abandonment is a necessary topic and the allowance for execution covers the final intervention in case the results are under expectation or none.

18. Do you know if orphan wells exist in your country? How do you get this information?

Yes, they exist. This information is hard to get, and it is not public. It's something under radar, usually its connected to not willing to take over the abandonment cost an there are no found for exsecution.

Data, possible uses and utilization

Data in this section concern the knowledge about information to define the usability of a well (geology, hydrogeology, reservoir stuff…)

19. Are there requirements to report drilling plans and well data after drilling to authorities in general? If yes, which information/data has to be provided?

Yes, there is prescribed in the law for two options:
- Production/Concession under Mining act
  ○ Overtake all collected data after the concession finished and abandonment of the concession area is done.
- Production/Concession under Water Act
  ○ After research drilling the investor needs to overhand to Direktorate for underground waters following information:
  ▪ Geological and Hydrogeological data collected from the formation.
  ▪ Measurement data, calculations and interpretation.

20. Is this data or parts of it publicly available for free or at least partly free?

No, the data is in the MINING BOOK register, it's possible to have a inside look to relevant data but it is a procedure, and we are not sure about availability of all data. The Geological Institute of Slovenia has by law the right to collect drilling samples and material during explorational drilling and other date if agreed with the investor. Usually, this option is rear used.

21. Who is data owner of raw data (well data, log data etc.)?

The investor of the data. After intervention some data are overhanded to authorized authority listed in the document that allows the intervention. Such data is filled to the Mining book an accessible to Geological Institute of Slovenia. As stated above, after concession expires the data shall be overhanded to the authorized authority listed in the document that allows the intervention

22. Who is data owner of data interpretations (based on this well data or seismic data)?

The investor of the data. After intervention some data are overhanded to authorized authority listed in the document that allows the intervention. Such data is filled to the Mining book an accessible to Geological Institute of Slovenia. As stated above, after concession expires the data shall be overhanded to the authorized authority listed in the document that allows the intervention

23. What is the attitude of companies/authorities regarding to provide data from wells or to make well data available to the public? Do have any experiences with this?

Depends on data and open mindedness of the data holders. Usually its hard to get any data, because of fear to abuse the information for other purposes such ad additional tax, other expenses pile up because of monitoring obligations and potentially pollution with overheated water into environment, etc.

24. Where are well databases stored (at commercial company, administrate organisation, authorities, universities and/or others as e.g. web maps, web services)? Please list them with references.

COMPANIES: ***Oil and Gas*** Petrol Geo d.o.o., Petrol Geo d.o.o. | Petrol Ascent Slovenia Limited d.o.o., Geoenergo d.o.o. Geoenergo d.o.o. | Petrol ***District Heating with geothermal*** Petrol Geo d.o.o., Petrol Geo d.o.o. | Petrol ***Balneology and Spa*** Sava Turizem d.d. Sava Hotels & Resorts - Bled, Portorož, Radenci, Moravske Toplice, Ptuj (sava-hotels-resorts.com) Terme Čatež Terme Čatež (terme-catez.si) Terem Krka Terme Krka (terme-krka.com) ***Agriculture – green house*** Paradajz d.o.o. Lušt (lust.si) Ocean Orhids d.o.o. Ocean Orchids – We understand flowers **MUNICIPALITIES:** Murska Sobota Murska Sobota | Murska Sobota (murska-sobota.si)

Moravke Toplice Občina Moravske Toplice | V slikoviti pokrajini Prekmurja (moravske-toplice.si) Benedikt, Občina Benedikt Dobrovnik, Občina Dobrovnik / Dobronak Község Lendava, Občina Lendava - Lendva Község **ADMINISTRATORS:** Mining Book, Rudarska knjiga (geo-zs.si) Geological Institute of Slovenia GeoZS (geo-zs.si) IRGO IRGO **UNIVERSITIES:** Faculty of Science and Technology Naravoslovnotehniška fakulteta - NTF (uni-lj.si) **WEB:** Atlas okolja Atlas okolja (gov.si) Mining Book, Rudarska knjiga (geo-zs.si)

25. List categories of well data, which are freely available for the public (at commercial company, administrate organisation, authorities, universities and/or others as e.g. web maps, web services).

Name, location, depth, diameter of the well, temperature

26. Estimate and describe in which formats most of the data is available. Is the data in digital formats, or is it scanned, in paper format or in another format (e.g. microfilm?).

Digital formats, pictures, sketches, pdf, ppt, paper,..

27. Who is responsible for well integrity before establishing the recompletion for reuse?

User of the well or the owner.

28. How does the ownership of a well can be changed? Is it a simple contract between two parties or are there any legal obligations to consider?

It's a simple contract between two parties overhanding/overtaking the responsibility and object.

29. What are the requirements for the new owner/leasing (e.g. proof of capital)? Is a well owner change related to a change of production licences if applicable?

The new owner needs to drill the well and have capital for it or buys the existing well and overtakes it in condition as it is. The well owner can also change in case of change of production licence, but this procedure is different and there needs to be a bank guarantee of other proof of capital behind the deal.

30. Are obligations transferable to another owner/for lease? If yes, is it a common procedure?

Yes the obligations are transferable o

31. Are there requirements of well integrity tests before and/or after recompletion (e.g. special surface equipment for possible hydrocarbon leakage)?

Yes, during the completion is a necessary to check the integrity, in the mining project for execution there are listed integrity tests and pressure rating for equipment and procedures have to check this. Additional on a 5 a 10-year basis there are visual checks and integrity checks for equipment under pressure therefore those things shall be checked accordingly to legislation. Real life some do checks other not.

Legal framework, licensing/administration

This section focuses on regulatory approval for a well reuse. At this point, it should already be clear how the well will be used and what measures will be required (e.g. installation of tubing, drilling side tracks, extending the depth, productions tests…).

32. Resource – Does your country consider geothermal heat as a raw material? If yes, what is the legal base?

We have 2 options, depending on the concession the investor wants to produce the geothermal waters. Again, different law fundamentals: - Water Act – open loop system with possibility to inject up to 80% of the water used. - Mining Act – closed loop system with 100% injection of the water used. Geothermal heat is defined as raw material in case Mining law is applicable and a 100% reinjection rate is established.

33. Who owns the resource? Down to which depth?

The resource is state owned, and the user is granted with a concession for extraction/production to a flow rate connected to the well testing performances and a hydrological report which is undergoing rechecking within the monitoring prescribed timeframe. I think there are periods for yearly and 3-years checks.

34. Do you need an extra permit for workover? How is a recompletion handled? Is it different if the owner and the purpose of use change?

No extra permit for workover, in case no big intervention is performed. In case of a cleaning or equipment change no permit is required. In case of stimulation, acidizing, redrilling or bigger recompletion a water consent in necessary for the intervention.

35. Please, briefly explain the legal basis for the approval of geothermal systems (consider the different application forms for geothermal energy e.g. deep BHE, pumping/reinjection well for HE) in general in your country. Which legal instruments apply and are they valid for a reuse? At which legislative levels are these regulations valid and executed (national level, regional level, local level)? Is the process comparable to that for a reuse? Please note differences between the reuse methods.

Water ACT - Mining project for the planned intervention - Application for the underground water research permit - Application for the water consent - Application for the preliminary screening

- Drilling the well and testing
- Reporting and Hydrogeological report
- Filing Application for concession granting
- Concession is granted under the Water law.
- Environmental consent

Mining ACT

- Mining project for research concession
- Application for the concession
- Concession granted.
- Mining project for the planned intervention
- Application for the drilling permit
- Application for the water consent
- Application for the preliminary screening
- Drilling the well and testing
- Reporting and Hydrogeological report
- Application for the production concession
- Concession is granted under the Mining law.
- Environmental consent

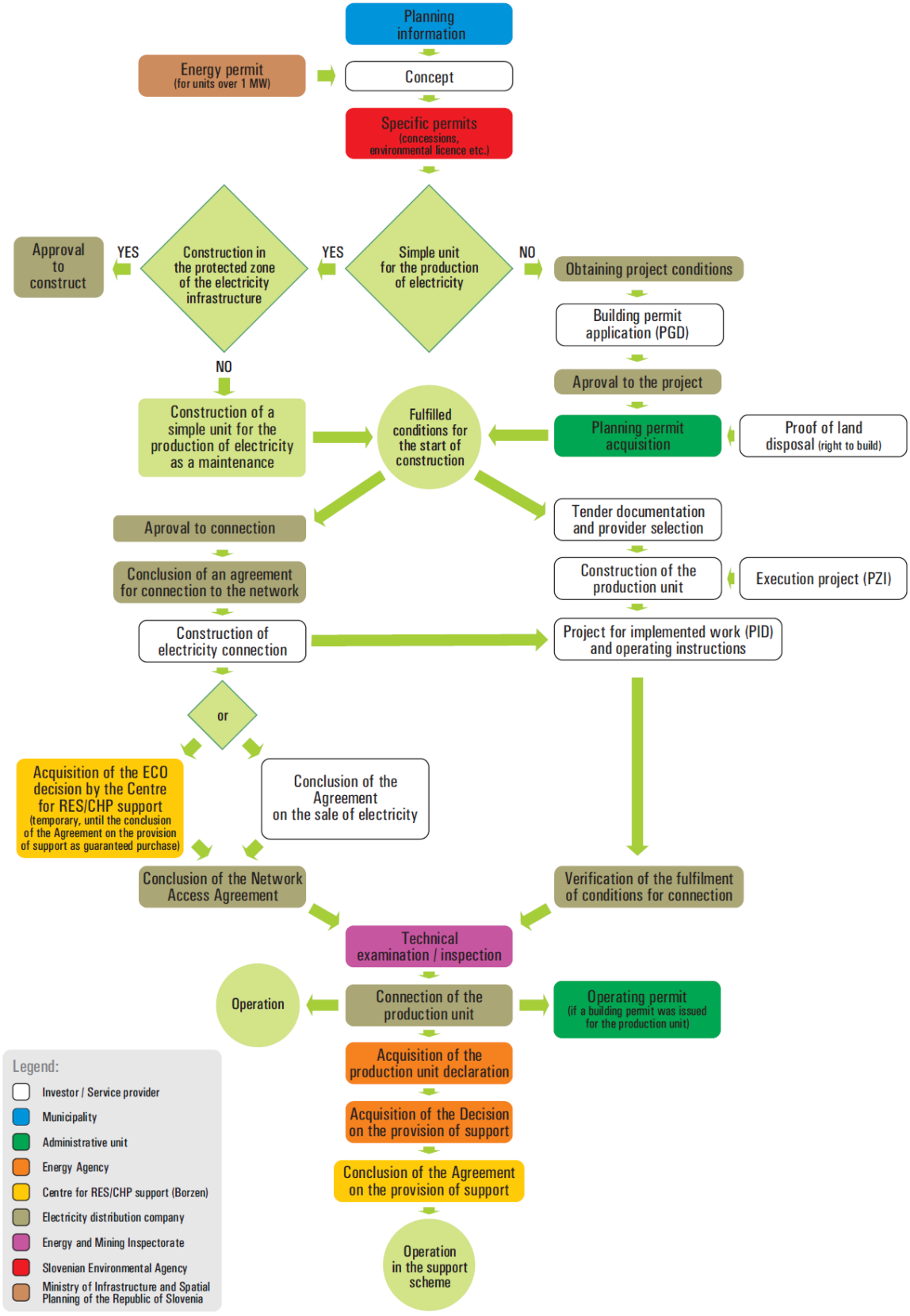
For all the state level is applicable, no local legislation is overruling the state legislation. For all theologies the process is the same the change can be the starting phase is the wells are already there other thing are as listed and connected to the applicable legislation for a close-loop system or a open-loop system.

36. What exactly needs to be approved for geothermal energy plants - the installation of the equipment and/or the energy generation? Concerning latter, is it the use of heat, the use of water or the influence to the environment/water for example?

There following thing needed:

- Concession for production (hydrogeological report, testing report, agreement with the Sate for the validity period of the licence,…)
- Building land for wells and surface facilities (power plan, access roads, pipelines,…)
- Energy Permit
- a final building permit,
- evidence of "right to build" (right of ownership on land) for the entire route of the connection. In the case of connection site property transfer to the distribution company, the easement right or ownership must be granted to the distribution company.
- the project of implemented work (PID) for connection must contain all binding schemes and surveying the track of the connection in all spatial dimensions in written and electronic form (in the case of a new or reconstructed connection).
- a statement by the installation contractor and the connector contractor for the conformity of all electrical installations and connection must be obtained. Beside the project documentation also the consent granted for the connection and the applicable regulations must be provided (in the case of a new or reconstructed installation),
- a permanent contract for the maintenance and use of the connection, in so far as it is not owned by the electricity distribution company.

- operating instructions for the facilities for which this is required (in the case of a new or reconstructed installation).
- other data and documents relating to access to the network in accordance with Article 29 of the SPDOEE. In the event of an incomplete application, the investor shall be invited for completion. After the completeness of the application, the conformity of the connection with the conditions laid down in the consent given for connection and with the design documentation shall be verified.
- Below is the flow chart form idea to distribution of electric energy.


Planning information
Energy permit (for units over 1 MW)
Concept
Specific permits (concessions, environmental licence etc.)
Approval to construct
YES
Construction in the protected zone of the electricity infrastructure
YES
Simple unit for the production of electricity
NO
Obtaining project conditions
Building permit application (PGD)
Aproval to the project
NO
Construction of a simple unit for the production of electricity as a maintenance
Fulfilled conditions for the start of construction
Planning permit acquisition
Proof of land disposal (right to build)
Aproval to connection
Tender documentation and provider selection
Conclusion of an agreement for connection to the network
Construction of the production unit
Execution project (PZI)
Construction of electricity connection
Project for implemented work (PID) and operating instructions
or
Acquisition of the ECO decision by the Centre for RES/CHP support (temporary, until the conclusion of the Agreement on the provision of support as guaranteed purchase)
Conclusion of the Agreement on the sale of electricity
Conclusion of the Network Access Agreement
Verification of the fulfilment of conditions for connection
Technical examination / inspection
Operation
Connection of the production unit
Operating permit (if a building permit was issued for the production unit)
Acquisition of the production unit declaration
Acquisition of the Decision on the provision of support
Conclusion of the Agreement on the provision of support
Operation in the support scheme
Legend:
Investor / Service provider
Municipality
Administrative unit
Energy Agency
Centre for RES/CHP support (Borzen)
Electricity distribution company
Energy and Mining Inspectorate
Slovenian Environmental Agency
Ministry of Infrastructure and Spatial Planning of the Republic of Slovenia

37. Is there a difference in the licensing if you will produce heat or power?

No, the licensing is the same. Civil works are different, and the footprint is different. Also, environmental permits are different.

38. Are there different regulations for different depth levels?

No regarding the underground. Surface depends on the intervention and regulation.

39. Is there a difference in permitting concerning the different possibilities of reuse?

No regarding the underground. Surface depends on the intervention and regulation.

40. Are there legal requirements for monitoring?

Yes, we have prescribed monitoring programs, that need to be fulfilled and reports need to be submitted to authorized authority – Environmental Agans of Slovenija (ARSO) www.arso.gov.si

41. What kind of permits or working plans is needed, if testing is needed?

Water ACT - underground water research permit - water consent - Application for the preliminary screening - Environmental consent Mining ACT - drilling permit - water consent - Application for the preliminary screening - Environmental consent

42. How is the permitting procedure to drill a side-track or to expand the depth of an existing well? What are the legal requirements?

For the permitting is the same procedure: Mining project for execution Water ACT - underground water research permit - water consent - Application for the preliminary screening - Environmental consent Mining ACT - drilling permit - water consent - Application for the preliminary screening - Environmental consent

43. Are there specific environmental regulations in place for well reuse, and if so, what are they? Is there an obligation for an environmental impact analysis?

No. A preliminary screening is necessary before intervention of drilling.

44. Do you know any reasons why a reuse or the recompletion is forbidden? (e.g. region was repurposed as environmental protection zone…)

No reasons.

45. Which entities are involved in the licensing procedure?

Ministry of natural resources and space ○ ARSO – Environmental Agency of Slovenia, www.arso.gov.si ○ Directorate for waters, Direktorat za vode | GOV.SI ○ Mining department, Sektor za rudarstvo | GOV.SI

46. Who is the authority to supervise the repurposing process of abandonment wells?

Inspectorate for natural resaurces and space, Inšpekcija za naravne vire in rudarstvo | GOV.SI

47. Is there a One-stop shop system for application (one responsible authority for the execution of a licencing procedure)?

No. There are few applications which need to go to certain authorised authority connected to the location of intervention.

48. Is an online application possible?

Yes and very often used, you can immediately get the confirmation of receipt and its faster and easier for document filling.

49. How long does a permission procedure take? Are there maximum time limits for procedures? Is there automatic permission after a deadline passed?

Depends on the stage of the project: Mining project for execution –> 45 days Water ACT - underground water research permit -> 15 – 20 days - water consent-> 15 – 20 days - Application for the preliminary screening -> 40 – 60 days - Environmental consent -> 30 – 60 days Mining ACT - drilling permit -> 15 – 20 days - water consent-> 15 – 20 days - Application for the preliminary screening-> 40 – 60 days

- Environmental consent -> 30 – 60 days

There are maximum limits but nobody can do anything if they are due and the application is not solved. NO automatic permission is possible, a document from the responsible person leading the procedure is mandatory.

50. How long is a permit valid?

Water ACT – max 30 years; Mining ACT – max 50 years

51. Is the permission related to special obligations during the installation and operation (e.g. reporting of production data)?

Yes, there are reporting, monitoring, maintenance, inspection checks etc. All needs to run accordingly to the permit/concession there are listed breaches under which the permit/concession can be terminated if the permit/concession holder is not fulfilling obligation under the agreement between signed with the State.

Part 2 – Financial framework

The purpose of this questionnaire is to provide an overview of the financial framework for geothermal applications for reuse of existing wells.

Please note that reuse may require additional infrastructure compared to a conventional geothermal project because reuse is tied to existing sites. This means that heat exchangers or pipelines will be required to mitigate the reduced heat output.

Financial framework and funding

National funding

52. Is there national funding for geothermal applications based on reuse of existing wells? List the funding available. If yes, please name it, give a reference, purpose, and amount. Who is eligible for a given programme or funding source? - If not, are there suitable alternative funding schemes, which can be used for this purpose?

Exclusive financial resources for applied use of geothermal energy from existing wells do not exist. In this case, we are talking about indirect financing of the project in the form of traditional or innovative financial instruments.

The **following financial instruments** are possible for the given content of the project:

- At the national level with subsidies, tax reliefs and grants that are in the domain of the ministries (Ministry of Environment, Climate and Energy, Ministry of Natural Resources and Space, Ministry of Cohesion and Regional Development).

- In the form of co-financing (3rd Party Funding), which are in the domain of public funds (Eco Fund).

- In the form of loans and mortgages, which are the domain of the banking sector.

- In the form of co-financing - private sector.

53. Which are the typical timeframes for funding? Which types of the project they are covering (e.g. feasiblility process, installation, operational phase). What are the requirements for funding?

The **timeframes for funding** for projects involving the reuse of existing wells can vary depending on factors such as the condition of the wells, regulatory requirements, project scope, and financing sources. General overview of typical timeframes in Slovenia is:

Assessment and Planning: The initial phase involves assessing the existing wells to determine their condition, suitability for reuse, and potential for generating geothermal energy or other resources. This phase can include feasibility studies, site assessments, and preliminary engineering. Depending on the complexity of the project, this phase can take several months.

Permitting and Regulatory Approval: Reusing existing wells may require obtaining permits and regulatory approvals from relevant government agencies, such as environmental permits, drilling permits, and land use permits. The timeframe for permitting can vary depending on the regulatory framework and the complexity of the project but typically ranges from several months to a year or more.

Financing: Securing funding for the reuse of existing wells can involve various financing sources, such as project finance, equity investment, debt financing, grants, and government incentives. The timeframe for securing financing depends on factors such as the size of the project, the availability of financing options, and market conditions. It can take several months to a year or more to secure financing for the project.

Well Rehabilitation and Infrastructure Development: Once funding is secured, the project moves into the implementation phase, which involves rehabilitating the existing wells, installing surface infrastructure, and potentially drilling new wells or conducting workovers to enhance productivity. The timeframe for this phase depends on the scope of work and the condition of the existing wells but can typically range from several months to a year or more.

Commissioning and Operations: After the wells and infrastructure are rehabilitated and upgraded, the project enters the commissioning phase, where systems are tested and operations are optimized. Once commissioned, the project begins generating revenue from the sale of geothermal energy or other resources.

Requirements for funding

Securing funding for the reuse of existing wells, whether for geothermal energy production or other purposes (reinjection), typically involves meeting certain requirements. Key aspects that investors or funding sources must consider in Slovenia:

Project Viability and Feasibility Study: Investors will want to see a comprehensive feasibility study demonstrating the technical, economic, and environmental viability of reusing the existing wells. This study should assess factors such as well condition, reservoir characteristics, resource potential, infrastructure needs, and projected costs and revenues.

Legal and Regulatory Compliance: Projects must comply with all relevant laws, regulations, and permitting requirements. This may include obtaining permits for drilling, water use, environmental impact assessments, land use, and any other regulatory approvals necessary for the project.

Technical Expertise: Investors will assess the technical capabilities and expertise of the project team, including geologists, reservoir engineers, drilling engineers, and other professionals involved in well rehabilitation and geothermal energy production.

Financial Projections and Risk Assessment: A detailed financial model should be developed to estimate project costs, revenues, and cash flows over the project's lifespan. This should include sensitivity analysis to assess the project's sensitivity to key assumptions and risks. Investors will also want to understand the project's financing structure, including the mix of equity and debt financing, as well as any government incentives or grants.

Market Analysis and Offtake Agreements: A thorough market analysis should be conducted to assess demand for the project's outputs, whether it's geothermal energy, hot water, or other resources. Offtake agreements or power purchase agreements (PPAs) with credible counterparties can provide assurance of revenue streams and may be required by lenders or investors.

Environmental and Social Impact Assessment: Investors will want to understand the potential environmental and social impacts of the project and how these will be managed and mitigated. This may include assessments of water usage, emissions, land use, and impacts on local communities.

Risk Management and Mitigation Strategies: Investors will expect to see a comprehensive risk management plan that identifies potential risks to the project and outlines strategies for mitigating these risks. This may include technical risks such as reservoir performance, drilling risks, and operational risks, as well as financial and market risks.

Exit Strategy: Investors will want to understand the project's exit strategy, including options for monetizing their investment, such as project refinancing, sale to a strategic investor, or public offering.

Traditional and innovative financing options

54. Are there examples of financing options in your country listed in the Figure below? If so, please name and describe them.

Financing Instruments for Building Efficiency

SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

	Traditional	Innovative	
Non Repayable	Prizes, Subsidies and Grants Tax incentives	Energy Efficiency Feed-in Tariff	
Debt	Loans / Mortgages Credit Enhancers: Guarantees, Securities, Insurances, Additional Collateral, etc.	Green Loans / Soft Loans Green Bonds, Community/ Municipal Investment Bonds, Social Bonds Energy Performance Contracting (EPC) / Agreements (EPA)	Energy Service Agreement (ESA) Green Leasing, PACE Energy Efficient Mortgages On-Bill Financing Loans / Tariff Green Revolving Funds Crowdfunding
Equity	3rd Party Funding (Business Angels)	Energy Communities, Energy Cooperatives	
Other	Advisory Services Technical & Project Dev. Assistance Capacity Building	Energy Efficiency Quota Obligations One-Stop Shops	

Examples of financing options for the reuse of existing wells in Slovenia:

Grants and Subsidies: Government agencies, development banks, and non-profit organizations may provide grants or subsidies to support projects involving the reuse of existing wells for geothermal energy or other purposes. These grants may cover a portion of the project's capital costs, reduce financing costs, or provide other financial incentives to encourage investment in sustainable energy projects. Funding entities in Slovenia: Ministry of Environment, Climate and Energy, Ministry of Natural Resources and Space, Ministry of Cohesion and Regional Development).

Eco Fund, Slovenian Environmental Public Fund (Eco Fund), main purpose is to promote development in the field of environmental protection by offering financial incentives such as soft loans and grants for different environmental investment projects.

It began with soft loans for investments in environmental protection as a revolving fund. Perhaps the most significant aspect of Eco Fund's operating environment is the requirement that Eco Fund maintains the real value of its assets. For this reason, Eco Fund has provided support to environmental investments through soft loans and developed a strong focus on the financial sustainability of the projects it supports.

Debt Financing: In addition to project finance, project sponsors may also secure traditional debt financing from banks or other financial institutions. Debt financing can be used to cover a portion of the project's capital costs, with repayment structured over a predetermined term and with fixed or variable interest rates. Debt financing may require collateral and may be subject to credit checks and other lending criteria. Funding entities in Slovenia: banks and other financial institutions).

Equity Investment: Equity investment involves raising capital from investors in exchange for ownership stakes in the project. Equity investors may include venture capital firms, private equity funds, institutional investors, or individual investors. Equity investment can provide the project sponsor with capital without the obligation to make fixed interest payments, but it typically involves sharing ownership and control of the project. Funding entities in Slovenia: Investors and other private sector.

55. Are there any other financing options in your country or do you know about any other in general (e.g. can be an example from another country)?

We have no additional information regarding other financial instruments.

Other incentives

56. Are there any financial incentives for companies to locate in regions where abandoned wells are situated? If yes, please give a short description.

According to current data, there is no public financial platform for investors with the possibility of locating and investing in individual abandoned wells.

57. Does development or strategic planning for regions with abandoned wells exist?

There are no specifically defined strategic development plans for the use of existing wells. An approach to the strategic plan for abandoned wells is the mining project for the rehabilitation of wells, which defines the status of all wells (existing and converted) in a certain mining area.

Appendix 3 - Questionnaire Germany

Author and country update on well reuse

Author	LBGR (geological survey, and mining authority) Katrin Sieron, Sebastian Weinert
Organisation	LBGR
Country	Germany
Contact	Katrin.Sieron@lbgr.brandenburg.de

Executed projects: Do reuse projects exist in your country? If yes, please indicate the name, starting date, approximate duration of use, project partners and a short description.

Not at the moment, but there are “future projects”

1. Do you have information about the procedure for reuse of wells and about lessons learned from practice? If so, please describe them.

No, we don´t have any at the moment.

2. Are there reuse projects in the planning phase? If yes, please indicate the name and a short description, if possible.

1 in the planning phase (Brandenburg State; in other States, there are more): Crude oil and natural gas drilling project (industry), with indication of a second use for Geothermal energy if not successful and/or after exploiting oil/gas; Geothermal use practically might happen after 10-20 years

3. Is the reuse of wells a political topic in your country? E.g., do national, regional or local energy plans mention well reuse? Do companies/others show interest in well reuse?

National, regional, local energy plans – yes (at least planning phase) e.g. https://www.bmwk.de/Redaktion/DE/Pressemitteilungen/2022/11/20221111-geothermie-fuer-die-waermewende.html; companies show interest in reuse – yes (we know of 2 Municipal utilities)

4. We are considering the reuse of wells as deep geothermal utilizations. Is there a depth defined in your country that marks the start for deep geothermal? Do you think the reuse of wells makes sense at shallower depth?

Not really. Commonly starts at 1000 m, although some definitions include depths from 400-1000 m (might be useful for BTES/ATES exploration or district heating); >400 m deep well and needs approval from Bergamt

Data, well ownership and well condition

Data in this section concerns the knowledge about the existence of wells – availability, ownership, storage (how to find a well and its owner)

5. What industries are there in your country that use/need boreholes?

Hydrocarbon, underground storage (Gas), Mineral exploration, geothermal energy, Research drillings

6. How many of these companies are operating in your country (please separate between the industries, if applicable)? How many wells are there in your country (give only an estimate)?

**just Brandenburg State • Hydrocarbon: basically two companies with ca. 650 wells (according to Geodab db); in Germany about 25,000 • Underground storage (gas): 1 main company with ca. 159 (according to Geodab db); 5 for CO_2 storage • Mineral exploration: 1 main company; 86 copper ore, 49 iron ore, 16 halite and potash salt, 7 Wolfram (according to Geodab db), • Geothermal energy: municipal utilities/Balneology - 18 • Hydrology: 14 • (another 168 are drillings for geological mapping purposes)

7. If applicable: For these industries, are there any legal differences between the drilling of a well and the use of a well?

   Are special permits necessary (please indicate the legal basis)? Does this affect the reuse of a well? Please explain if yes.

Permits are on resources (e.g. hydrocarbon); if heat/brine is of interest, a new permit/licence is needed. In addition, further permits are required, e.g. mining law (approval of the operating plan), water law, nature conservation law. This depends on the specific circumstances of the individual case.

8. Is there publicly-available data on existing wells? What information does this data include (e.g., owner, production status, depth, age)? Please also explain if this database is complete for your country (are all existing wells in this database) and if there are differences between the different industries.

Stammdaten/Nachweisdaten (Master data) publicly available (Nachweisdaten are data that assign the content of the geological investigations in terms of person, place, time and general content) (reuse from petroleum wells to heat/brine is easier than the other way around – (natural reserve laws etc). Database complete? (recent data yes, very old drillings not)

9. Is there any information publicly available about the well conditions - is it still open, permanently or temporarily abandoned? Are there data available on the abandonment works? If yes, how can they be accessed?

Data are available at the mining authority (we have access). There are also opportunities to view documents on the basis of the Environmental Information Act.

10. Must the existence and status of a well be reported? If so, to whom?

Yes, the status is reported to the mining authority.

11. Who owns a well and its equipment? Is it the person who drilled the well, the state or someone else? (Please separate between the industries if applicable)

Generally, the well is owned by the company/investor (different from the "operator" that effectuates the drilling itself). Some wells are transferred to State property. There is no differentiation between industries. When monitoring (mining authority) ends (drill hole cemented etc.), the drilling site goes back to the original owner of the land.

12. Is the land where surface facilities are placed mostly leased or company-owned?

Mostly leased.

13. Are there regulations on how to manage wells that are not used for the intended purpose or are no longer used? If so, what is the legal basis for this?

If wells are not used for intended purpose, a new permit needed. If wells are no longer used, a new operation plan (Betriebsplan), and a new permit is needed. Legal Basis: Bundesberggesetz regulates such affairs. Generally; abandoned wells must be cemented.

14. What is the common timeframe for well abandonment since production stop?

Normal case: 1-2 years (no reuse plan); but decision made on particular cases (by mining authority; see answer to 13.)

15. Is there any procedure the abandonment is tackled today?

The abandonment is regulated by the closure plan (Abschlußbetriebsplan)

16. According to the law, how long can a well be kept shut-in or temporarily abandoned without production? What is needed (e.g., field development plan if other drilling locations are planned, production licence, etc.)?

According to the legal requirements of mining law, the final operating plan must be submitted if the use of the well is interrupted for two years. A longer interruption is only permissible with the consent of the mining authority. For other drilling locations, a new operation plan is needed. Some wells are still "open", as the regulations of former times were different.

17. Are there obligations to consider (immediate) reuse of a well, if a project was not successful in terms of its planned purpose?

No. But the obligation for the plugging process with a final operating plan (see answer to 12).

18. Do you know if orphan wells exist in your country? How do you get this information?

There are. Most of them are shallow (deep wells are generally well-documented); mining authority has everything there is (oldest evidence for drillings (oldest documented petroleum drilling from around 1858) are a few hand-written sheets of paper - -incomplete for obvious reasons). Several problems with legal ownership of East German wells.

Data, possible uses and utilization

Data in this section concern information available to define the usability of a well (geology, hydrogeology, reservoir details)

19. Are there requirements to report drilling plans and well data after drilling to authorities in general? If yes, which information/data has to be provided?

Drilling plans need to be reported beforehand. Data is to be sent obligatorily to the mining authority and the geological survey.

20. Is this data or parts of it publicly available for free or at least partly free?

Depends on the type of data (in Germany, the “law for geological data” comprises three types of data (Nachweisdaten, Fachdaten und Bewertungsdaten). The first group of data (Nachweisdaten; Master data) is publicly available; Fachdaten (second type of data that comprises technical/geological “measured” data as for example borehole measurements and bore logs that is not “interpreted”. They can be purchased from the company or the LBGR or under certain circumstances (purpose of the use of the data with public benefit) gotten for free. IMPORTANT here: the categorization of data into the three groups is made by the LBGR and takes some time; differentiation between private drillings (+industry) and State drillings. The “interpretation data” is not available (only if owner agrees), but technical “measured data” is free after 10 years (industry) or 5 years (other private drillings) or always (State; research etc.)

21. Who is the data owner of raw data (well data, log data, etc.)?

Most of the raw data (Fachdaten) is company-owned but also stored at the Geol. Survey. Depending on the data categorization, raw data is mostly technical/geological data (Fachdaten), and hence the survey can provide them.

22. Who is the data owner of data interpretations (based on the well data or seismic data)?

Data interpretations are owned by the company (mostly). Interpretations are commonly “Bewertungsdaten” (valuation data) and aren´t available to the public (Exception= research drillings)

23. What is the attitude of companies/authorities regarding providing data from wells or making well data available to the public? Do you have any experience with this?

The authority is obliged to provide technical data (Fachdaten; see 16), Nachweisdaten (Master data) are publicly available. The attitude depends on the company, the purpose of the use of data etc. The private companies usually try to gain an economic benefit from marketing the data for a fee.

24. Where are well databases stored (at commercial companies, administrative organisations, authorities, universities and/or others as e.g., web maps, web services, etc.)? Please list them with references.

The most comprehensive db is located at the LBGR (Geodab). Data is certainly stored at the companies, but not publically available.

25. List categories of well data which are freely available for the public (at commercial companies, administrative organisations, authorities, universities and/or others as e.g., web maps, web services, etc.).

*Master data (Nachweisdaten) are digitally available (LBGR website) and include well-ID; well-name; coordinates, final well depth; course of borehole (eventual deviations) (LBGR Geodab additional data: map sheet number; height system; location; project; company; type of drilling); database quite complete for deep drillings (not so for shallow drillings <200m) *Technical/geological data (Fachdaten) is partly digital (partly just available at the company; scanning campaign coming soon?)

26. Estimate and describe in which formats most of the data is available. Is the data in digital formats, or is it scanned, in paper format or in another format (e.g., microfilm?).

Master data are digitally available (and complete for deep drillings); Technical/geological data (Fachdaten) are partly digitally available (bore logs, certain borehole measurements; Geodab db-partly as scan); rest is analogue (on paper; digitizing is aimed at near future)

27. Who is responsible for well integrity before establishing the recompletion for reuse?

The mining permit/licence holder and the mining contractor who managed the mining operation. These may be identical or different persons or companies.

28. How can the ownership of a well be changed? Is it a simple contract between two parties or are there legal obligations to consider?

It is possible to transfer the ownership with a contract. Contracts for the transfer of the permission or the licence require the approval of the mining authority.

29. What are the requirements for the new owner/leasing operator (e.g., proof of capital)? Is a well owner change related to a change of production licences?

See answer to 24. Proof of capital; proof of resource or exploration program; in case of production, a licence (permit needs to be updated; check BBergG §11-13)

30. Are obligations transferable to another owner/operator? If yes, is it a common procedure?

It’s possible, but not a common procedure (1 case – Reudnitz in Brandenburg, after the German reunification). Generally, the obligations are bond to the owner, but would be transferred to the new one (if no special agreement is made beforehand; special cases with ex-East Germany wells – Treuhand; exempted from remediation)

31. Are well integrity tests required before and/or after recompletion (e.g., special surface equipment for possible hydrocarbon leakage, etc.)?

Well integrity is checked before the use, after every “significant change” and every 6 years. Reuse – leak test; no new borehole measurements required

Legal framework, licensing/administration

This section focuses on regulatory approval for well reuse. At this point, it should already be clear how the well will be used and what measures will be required (e.g., installation of tubing, drilling side tracks, extending the depth, production tests, etc.…).

32. Resource – Does your country consider geothermal heat as a raw material? If yes, what is the legal basis?

Heat is a resource free for mining (bergfreier Rohstoff) – therefore BBergG applies (§3, Absatz 3 2b)

33. Who owns the resource? Down to which depth?

The resources do not belong to the owner of the land. The State has the right to issue the concessions(licences) (not dependent on depth – to the earth´s core)

34. Do you need an extra permit for workover? How is a recompletion handled? Is it different if the owner and the purpose of use change?

-Yes (depends on size) Recompletion →extra permit (new operational plan) -different if owner and purpose of use change? – no -Generally regulated by the operational plan/special operating plan

35. Please, briefly explain the legal basis for the approval of geothermal systems in general in your country. Consider the different application forms for geothermal energy (e.g., deep BHE, pumping/reinjection well for HE, etc.). Which legal instruments apply and are they valid for a reuse? At which legislative levels are these regulations valid and executed (national level, regional level, local level)? Is the process comparable to that for a reuse? Please note differences between the reuse methods.

National – (BBergG, UVP-V, etc); regional (State), local. There are no differences between the reuse methods.

36. What exactly needs to be approved for geothermal energy plants - the installation of the equipment and/or the energy generation? For example, is it the use of heat, the use of water, or the influence to the environment/water?

BBergG covers the technical installations and ends at Transmission station. In addition, a permit under the water law is required. For other facilities, such as pipelines and energy generation, permits are required under other areas of law, e.g. construction law.

37. Is there a difference in the licensing if you will produce heat or power?

No (not in terms of the mining law), but the approval of the heat or power generation plant is regulated by other legislations.

38. Are there different regulations for different depth levels?

Yes. BBergG starts at 100m; 100-200 no regulations in terms of the mining law; 200-400 m – individual case decision; >400 m BBergG obligatory (several other regulations issued by the mining authority)

39. Is there a difference in permitting related to the different possibilities of reuse?

Reuse - case-by-case decision

40. Are there legal requirements for monitoring?

Yes. This is regulated in different legal regulations, e.g. in the Environmental Impact Assessment Act, if the project is subject to EIA. In the sense of “mining supervision”, it´s also regulated (§69-74).

41. If testing is needed, what kind of permits or working plans are needed?

Well-testing is included in the operational plan (working plan), which itself is part of the application process

42. What is the permitting procedure to drill a side-track or to expand the depth of an existing well? What are the legal requirements?

Operation plan or Special operation plan, according to the BBergG

43. Are there specific environmental regulations in place for well reuse, and if so, what are they? Is there an obligation for an environmental impact analysis?

Yes. UVP-V Bergbau (EIA obligation for deep boreholes from a depth of 1,000 meters for the extraction of geothermal energy in nature conservation areas pursuant to Section 23 of the Federal Nature Conservation Act or in Natura 2000 and for deep boreholes for the exploration and extraction of geothermal energy with fracturing of the rock under hydraulic pressure, EIA preliminary assessment for other kinds of deep drillings) Reuse corresponds to the same procedure as “new use”. Example Leibsch drilling LPC/80.

44. Do you know any reasons why a reuse or the recompletion is forbidden (e.g., region was repurposed as an environmental protection zone, etc.)?

Theoretically yes (but as for today, no reuse was performed).

45. Which entities are involved in the licensing procedure?

Mining authority; BASE – Endlager; Wasserbehörde (Regionalbehörde); LFU; nature conservation associations (Naturschutzverbände – voluntary but strategically necessary); district (Landkreis – several authorities: monuments, archaeology, forestry, regional planning, military, etc)

46. Who is the authority to supervise the repurposing process of abandoned wells?

Mining authority

47. Is there a One-stop shop system for application (one responsible authority for the execution of a licensing procedure)?

Not generally. In some cases, yes, and the mining authority handles the different approvals (just in the case of licensing). In other cases, it may be necessary to obtain approvals from other authorities as well with a separate application (e.g. nature conservation authority). Theoretically, the ministry of Economics could function as one-stop shop system (but practically it´s the mining authority)

48. Is an online application possible?

No, but planned for near future.

49. How long does a permission procedure take? Are there maximum time limits for procedures? Is there automatic permission after a deadline passed?

Depends. Starting with xx?, parallel several applications? (permit 9-12 months; operation plan 3-4 months, special operation plan 3-4 m). No limits. Total – ca. 1 -1.5 years (last ones 3-5 years)

50. How long is a permit valid?

For reuse no licence admitted so far. (Permit – up to 5 years + a possible 3 year extension; licence up to 50 years + extension; operation plan 2 years, then extension or new one)

51. Is the permission related to special obligations during the installation and operation (e.g., reporting of production data, etc.)?

• Installation – data reporting is obligatory as well as actually undertaking the installation itself (exploration also obligatory + time-limited) (Feldesabgabeerklärung in case of a “permit”; annual Report of statistical data for brine – and geothermal heat (also for petroleum/gas) mining in case of “permit” and/or “licence”) • Reporting of production data – when operating already no reporting of production data, but annual reports (Förderabgabeerklärung) • Until 31.12.2025 no fees (mining royalties) for Geothermal energy

Part 2 – Financial framework

The purpose of this questionnaire is to provide an overview of the financial framework for geothermal applications for reuse of existing wells.
Please note that reuse may require additional infrastructure compared to a conventional geothermal project because reuse is tied to existing sites. This means that heat exchangers or pipelines will be required to mitigate the reduced heat output.

Financial framework and funding

National funding

52. Is there national funding for geothermal applications based on reuse of existing wells? List the funding available.
    If yes, please name it, give a reference, purpose, and amount. Who is eligible for a given programme or funding source?

    If not, are there suitable alternative funding schemes, which can be used for this purpose?

Germany nationwide programs

No specific national funding programs for geothermal applications based on reuse of existing wells are known.

Alternative funding schemes: the relevant federal funding guidelines may allow existing boreholes to be used (depends on specific program provider). Amount and who can apply for the funds also depends on the specific program. Depending on the latter sometimes the calls are for companies, but also communities, research institutions or universities.

Here, we list national Funding provider with fitting funding schemes for Geothermal energy:

Projektträger Jülich; Forschungszentrum Jülich (one of the leading project sponsors in Germany; support clients in federal and state ministries, federal authorities and foundations as well as the European Commission)

PtJ: Förderinitiativensuche (https://www.ptj.de/suche-foerderinitiativen):

They have time-limited request for proposals and permanent ones that potentially fit. We enlist several request for proposals of recent years or still active ones.

-„Geoforschung für Nachhaltigkeit (GEO:N)“ zur Förderung von Projekten zum Thema „Tiefengeothermie: Grundlagen für die Energiewende im Untergrund“ (“Georesearch for Sustainability (GEO:N)” to promote projects on the topic of “Deep geothermal energy: foundations for the energy transition underground”);
Eligible for funding: commercial companies, universities and non-university research institutions, municipal and state institutions as well as associations and other social organizations (such as foundations and clubs);
Funding provider: Federal Ministry of Education and Research (BMBF)

-Energieforschungsprogramm – angewandte nichtnukleare Forschungsförderung (Energy Research Program – applied non-nuclear research funding; funded by BMWK; for universities, research institutions, companies, communities, state offices)

-Geothermie (Geothermal energy in general; permanent)
https://www.ptj.de/projektfoerderung/angewandte-energiefoschung/geothermie
(financed by the Federal Ministry for Economic Affairs and Climate Protection)

-Thermische Kraftwerke (Thermal power plants; permanent)
https://www.ptj.de/projektfoerderung/angewandte-energieforschung/thermische-kraftwerke
(transformation of old infrastructure to be used by new resources; permanent request for proposals; financed by the Federal Ministry for Economic Affairs and Climate Protection)

-Ressourceneffizienz im Kontext der Energiewende (Resource efficiency in the context of the energy transition; permanent)
https://www.ptj.de/projektfoerderung/angewandte-energiewende/ressourceneffizienz-kontext-energiewende

Older requests for proposals include: Energy transition and society; Climate-neutral heat and cold; Possibilities and limits of thermal energy storage in aquifers –ATES; Use of underground geosystems; Energy storage research initiative, etc.
So potentially there can be several interesting future proposals

DFG (German Research Foundation)
-funds research proposals by single persons, research groups, etc.
-for example "Energy and material flow in the Upper Rhine Graben (ESOG): a systemic approach to describing the hydrothermal regime in graben structures" funded since 2020
-for research infrastructure, laboratory equipment etc.

Bundesamt für Wirtschaft und Ausfuhrkontrolle (BAFA)
- Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft – Zuschuss: Modul 2 Prozesswärme aus erneuerbaren Energien (Federal funding for energy and resource efficiency in the economy – Grant: Module 2 Process heat from renewable energies)
For companies; funding by BAFA
https://www.bafa.de/DE/Energie/Energieeffizienz/Energieeffizienz_und_Prozesswaerme/Modul2_Prozesswaerme/modul2_prozesswaerme_node.html

Bundesverband Geothermie (Federal Geothermal Association) – enlist Geothermal energy related projects, financed by several companies
Currently ongoing projects:
-Warm-up (since Nov 2022); Geothermal energy for the heat transition: supporting the rollout of medium-depth geothermal energy in Germany". The BGR is supporting the geothermal energy campaign "Geothermal energy for the heat transition" of the Federal Ministry for Economic Affairs and Climate Protection (BMWK); amount 2.785.147,65 EURO

State-funding (case Brandenburg)

The possible funding stemming from individual German states varies. In the case of Brandenburg there are the following funding opportunities:

-BEn 2023/2024 directive (The financial resources come from the Brandenburg Package. Therefore, applications can only be submitted until around May 2024. The directive ends on June 30, 2024 at the latest. BEn potentially funds studies and preliminary investigations of geothermal energy projects.
- The ERDF directive "Renewable Energies Brandenburg" is being planned and is expected to be launched in 2024.

In General – Press notes etc.

Press informs (2022) about the intentions of the Federal Ministry for Economic Affairs and Climate Protection to support the use of wells that are sought to be abandoned for geothermal energy (adapt mining law etc.); https://www.ingenieur.de/fachmedien/hlh/wissen/regierung-foerdert-nahwaerme-aus-stillgelegten-bohrloechern/

https://www.bmwk.de/Redaktion/EN/Artikel/Energy/research-priorities-deep-geothermal-energy.html
"…the Federal Ministry for Economic Affairs and Energy is helping to fund research projects which aim to make the use of geothermal energy more reliable and cheaper (cf. funding announcement for the 6th Energy Research Programme (PDF: 1.12 MB)).

One important focus of the ministry's research funding is to keep developing exploration methods in order to find appropriate sites. In view of high drilling costs, the risk of failure to find a suitable water reservoir or enough hot rock must be minimised. A lower risk of failure would also make the technology more attractive for investors.
Research is also focused on improving the level of public acceptance of geothermal projects. By providing the public with better information about the technologies in use and the benefits of this form of energy, the conditions can be put in place for the launch of further projects. Above all, however, it is necessary to cut the project costs further so that the technology can be used on a truly economically viable basis in future. Here, a role is played by the development of technology in all the various project phases: planning and exploration, drilling/construction, and test/operation."
https://www.bundesregierung.de/breg-en/news/future-technology-geothermics-2216188
"In order to be able to promote the use of geothermal energy more effectively, the Federal Government launched an initiative last year that includes funding for exploration projects. This cushions the risks involved and allows for exploration to find the most worthwhile locations for geothermal projects. "

https://climate.ec.europa.eu/news-your-voice/news/innovation-fund-additional-large-scale-geothermal-project-invited-prepare-grant-agreement-2022-12-19_en
"Under the second call for large-scale projects, a total of 17 projects were pre-selected for grant agreement preparation. Two of these projects did not successfully complete this process, allowing to invite this additional project from the reserve list. "

https://www.cleanenergywire.org/news/germanys-geothermal-sector-struggling-take
"….and since 2009 there have been modest subsidies for deep drilling. In 2020, for the first time, shallow geothermal received state support: namely rebates of up to 45% for drilling, ground source heat pumps, and other costs, when a building is replacing oil heating with renewable energy."
"Deinhardt applauds the federal government's new subsidies for drilling, even though, he says, what the geothermal sector really needs is fair markets that reward carbon-free energies that provide heat. The cost of drilling one well is about €10 million and every loop has two wells; they are thus the largest line item in geothermal development, which can run to €60 million for a single heat and power plant. The German investment bank's subsidy amounts to €2.5 million per borehole. A maximum of four deep wells can be funded per project."

https://renewablesnow.com/news/german-govt-plans-measures-to-tap-geothermal-potential-for-heating-804631/

https://www.mdpi.com/1996-1073/7/7/4397
Agemar et al., 2014
"The German Federal government supports the development of geothermal energy in terms of project funding, market incentives and credit offers, as well as a feed-in tariff for geothermal electricity."

Europe

- https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/ner-300-programme_de

Geothermal energy
European Parliament resolution of 18 January 2024 on geothermal energy (2023/2111(INI))
Document includes, among other statements:
- having regard to the European Commission study entitled 'Geothermal plants and applications emissions: overview and analysis'
-having regard to the Joint Research Centre report entitled 'The heat pump wave: opportunities and challenges

-having regard to the European Commission 2023 study entitled 'Overview of heating and cooling - Perceptions, markets and regulatory frameworks for decarbonisation
-having regard to its resolution of 10 July 2020 on a comprehensive European approach to energy storage7 and the Commission recommendation of 14 March 2023 on Energy Storage – Underpinning a decarbonised and secure EU energy system

53. Which are the typical timeframes for funding? Which types of the project they are covering (e.g. feasibility process, installation, operational phase).
    What are the requirements for funding?

Complete projects can be funded across all project phases, or in other cases only partial phases. As an example, the state of Brandenburg is currently only funding studies and preliminary investigations in the field of geothermal energy via the BEn directive (=Brandenburg Energy-package 2023/2024).

Overview **BEn 2023/2024** (3 March 2023 to 30 June 2024)
As part of the program, the ILB supports projects in the energy sector in order to alleviate the financial burden on companies caused by the energy shortage since the beginning of the Russian war of aggression against Ukraine.
Funding recipient: Companies and legal entities in the context of their economic activities
Funding topics:
-Energy saving projects (e.g. systems to improve energy efficiency or energy recovery),
-Use of renewable energies (e.g. renewable energy generation plants),
-Investment in district heating/cooling systems,
-Non-investment projects (e.g. concepts, preliminary investigations into geothermal energy projects, energy consulting)
Type of funding: grant
Funding provider: State of Brandenburg, Ministry of Economics, Labor and Energy (MWAE)
Source of funds: Brandenburg state
What is funded?
Investments, such as:
Energy efficiency improvements in technical process flows by saving electricity and/or heat,
Integration and use of renewable energy generation systems in technical process flows or heating networks,
Investments in district heating and cooling systems.
Non-investment projects, such as:
Development/creation of concepts, studies and preliminary investigations for geothermal energy projects,
Energy consulting services.
How does the funding work:
The funding is provided as project funding. The grant is granted as a grant. The amount of the grant depends on the respective requirements of the aid regime applied for (GBER or de minimis regulation).
You will receive in relation to the project
-up to 80 percent of eligible expenses,
-a maximum of **EUR 15 million** depending on the funding status according to the **AGVO** and the size of the company
-Up to 80 percent of eligible expenses for funding in accordance with the **de minimis** regulation (maximum **EUR 200,000**)

Traditional and innovative financing options

54. Are there examples of financing options in your country listed in the Figure below? If so, please name and describe them.

Financing Instruments for Building Efficiency

SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

	Traditional	Innovative	
Non Repayable	Prizes, Subsidies and Grants Tax incentives	Energy Efficiency Feed-in Tariff	
Debt	Loans / Mortgages Credit Enhancers: Guarantees, Securities, Insurances, Additional Collateral, etc.	Green Loans / Soft Loans Green Bonds, Community/ Municipal Investment Bonds, Social Bonds Energy Performance Contracting (EPC) / Agreements (EPA)	Energy Service Agreement (ESA) Green Leasing, PACE Energy Efficient Mortgages On-Bill Financing Loans / Tariff Green Revolving Funds Crowdfunding
Equity	3rd Party Funding (Business Angels)	Energy Communities, Energy Cooperatives	
Other	Advisory Services Technical & Project Dev. Assistance Capacity Building	Energy Efficiency Quota Obligations One-Stop Shops	

Depending on the funding provider, the financial options vary.
The most common ones include subsidies (certain percentage of the project costs); grants; and tax incentives
The latter is supported by the Law for the expansion of renewable energies, which gives incentives for "green" produced electricity (including Geothermal Energy); support for heat pumps
https://www.gesetze-im-internet.de/eeg_2014/index.html#BJNR106610014BJNE020303311

55. Are there any other financing options in your country or do you know about any other in general (e.g. can be an example from another country)?

European Investment Bank (EIB): invests in long term projects providing loans to companies. EIB is investing in green energy and provides the Energy Lending Criteria, defining a framework for support.
European Fund for Strategic Investment (EFSI): Investing 315 Mio. € in "riskier" projects which might cover exploration wells and compensates in case of failure. (until 2020 – extension proposed)
https://www.consilium.europa.eu/en/policies/investment-plan/strategic-investments-fund/
Several programmes at:
https://research-and-innovation.ec.europa.eu/research-area/energy/geothermal-energy_en

Other incentives

56. Are there any financial incentives for companies to locate in regions where abandoned wells are situated? If yes, please give a short description.

Not at the moment.

57. Does development or strategic planning for regions with abandoned wells exist?

(In process) Regional planning might include Geothermal Energy projects, but no reuse of old abandoned wells is included.

Appendix 4 - Questionnaire Croatia

Author and country update on well reuse

Author	Tomislav Kurevija, Marija Macenić, Danijela Vrtarić, Ema Novak
Organisation	University of Zagreb – Faculty of Mining, Geology and Petroleum Engineering (UNIZG – RGNF) Medjimurje Energy Agency Ltd. (MENEA)
Country	Croatia
Contact	tomislav.kurevija@rgn.unizg.hr;marija.macenic@rgn.unizg.hr; danijela.vrtaric@menea.hr; ema.novak@menea.hr

Executed projects: Do reuse projects exist in your country? If yes, please indicate the name, starting date, approximate duration of use, project partners and a short description.

Velika Ciglena

The exploitation field *Velika Ciglena* was developed with the use of exploration well VC-1 and VC-1A, originally drilled and equipped for hydrocarbon exploration and potential exploitation. After discovering the geothermal reservoir additional. Additionally, negative exploratory wells from the late 80's, VC-2 and Ptk-1, were further added to the geothermal field Velika Ciglena and are now used as additional production and injection wells in a setup 2+2. The Velika 1 geothermal power plant started with full capacity operation in March 2019 for 10 MW_e of installed capacity, out of 17 MW_e for which the plant was designed, according to power purchase agreement with the Croatian Energy Market Operator (HROTE).

Bizovac

The oil field Bizovac was discovered in 1967, with the hydrocarbon exploration activities in the Drava subbasin with the well Biz-1. In the same year two additional wells were drilled, with Biz-2 discovering a geothermal reservoir. In 1969 the well Biz-4 was drilled for the oil field exploitation; however it discovered larger quantities of mineralized geothermal brine at an approximate depth of 1760 - 1840 m. The wells assigned to the geothermal field produce the brine from the reservoir "Terme" (muscovite gneiss and to some extent in breccia conglomerate and sandstone) and the reservoir "A3" and "A4" (sandstone). The geothermal field started production in 1976 and still is producing today, with the wells Biz-2, Biz-4 and Slk-1 assigned to the field. The produced brine is used by the Bizovac hotel and spa complex and the concession licence holder for the geothermal field is INA d.d. Additionally, the GWR is around 1,6 m^3/m^3, and the produced gas is used also in the complex.

Ivanić

The Ivanić hydrocarbon & geothermal exploitation fields are specific because of their location in the middle of the city of Ivanić-Grad, with a population of around 15 000 people. The Ivanić hydrocarbon exploitation field was discovered in 1963 with the Iva-4 well, which identified economically significant hydrocarbon reserves in the gamma series sandstones, at depths more than 1500 m. Later, the presence of layers "I" and "K" sandstones, which are saturated with geothermal water, was determined within the oil exploitation field boundaries and are situated at an average depth of around 1280 m. The tests showed that geothermal "I + K"

series and hydrocarbon gamma series are not hydrodynamically connected. The Ivanić geothermal field has two wells assigned to it - Iva-1T and Iva-2, with Iva-2 previously used for oil exploitation but was later added to the geothermal field. The area covered by the Ivanić geothermal exploitation field is 2 x 2.5 km in size and within this area, there are 23 oil wells currently owned by INA d.d. The geothermal field was producing brine for the use in Naftalan Special Hospital (SNB) from 1988 until 2006 but due to lack of certain permits, the production was paused and was not continued. Today, legally, the Ivanić geothermal field is approved for exploitation of the shallower brine geothermal layer until 2027, with the company INA d.d. as a concession holder.

The *Ivanić* field still remains to have wider applicability, however the City is interested to used this potential for district heating, as well as add new potential once the oil field will be out of commission and to use remaining wells. This is also accepted by the public, especially from the environment perspective.

1. Do you have information about the procedure for reuse of wells and about learnings from practice? If so, please describe them.

The only reuse of wells in Croatia currently pertaining to reuse of the existing wells refers to geothermal brine production and repurposing exploration or exploitation wells in cases such as Velika Ciglena, Ivanić, Lunjkovec-Kutnjak, Babina Greda and similar projects. The existing wells, which are not under the concessions, and their respective data are state-owned with the Croatian Hydrocarbon Agency legally in charge of the data (well database).

2. Are there reuse projects in the planning phase? If yes, please indicate the name and maybe a short description.

Lunjkovec-Kutnjak

In the exploration field *Lunjkovec-Kutnjak* there are two existing wells, Lunjkovec-1 (Lun-1) and Kutnjak-1 (Kt-1) drilled in the 1960s and 1970s for the purpose of discovering hydrocarbons. The testing of the wells showed geothermal potential with achieved flow of high temperature water. Measured temperatures at the bottom of the wells ranged between 128 and 144 °C. The exploration licence was given in the bidding round in 2020 to Bukotermal d.o.o., a company owned by the County of Varaždin (85%) and the Municipality of Mali Bukovec (15%). In 2022 and 2023 well testing on both wells were conducted with results of 142°C at 2430 m of reservoir depth. Expected total installed power is around 16 MW with drilling new wells, besides revitalization of existing two. The project is envisioned to develop in a few phases. In the first phase the ORC power plant of 2 MW will use geothermal brine from already existing wells, where Lun-1 and Kt-1 wells are meant to work as a production-injection pair. It is expected that thermal energy for heating in the future development of the project will be around 90 MW.

Babina Greda

On this site old exploratory well Bag-1 from mid 80's was reworked and tested, giving a indication of flow and favourable temperature in range of 120-130°C. Development on this well is planned in a way to perforate deeper horizons which are believed to be very porous and highly permeable, with a brine temperature in a range of 170°C. This well is planned to be part of future geothermal doublet at the site.

Ernestinovo

Out of three existing exploratory wells drilled within the field Ernestinovo in the 1980s, the Ernestinovo -3 well was reworked in order to test the geothermal reservoir. The results are expected in the first quarter of 2024. According to preliminary assessments, it was estimated that the flow and temperature can ensure 10 MWe of power plant capacity.

Merhatovec

Newly awarded exploration field will use some of the existing wells in their respective areas at the moment. The *Merhatovec* will reuse both well at site which are equipped with the Christmas tree/wellhead and testing will be carried out. Whether it will remain as a production or an injection well is still unknown and it depends upon flow testing.

Slatina-2

Exploration site Slatina-2 is currently in testing phase of an old well from mid '80s, PS-5. It is very deep well with temperature in brine layers of more than 190°C. Plan is to use this revitalized well in a doublet with one new drilled well in near future for electricity production. Proposed power plant is planned to be ORC with 20 MWe.

3. Is the reuse of wells a political topic in your country? E.g., do national, regional or local energy plans mention well reuse? Do companies/others show interest in well reuse?

With the new geothermal exploration concessions awarded in 2023, the topic of utilizing geothermal energy, especially for electricity, has become very popular. The use of geothermal for heating purposes is also coming into the spotlight with mostly local municipalities interested. The Croatian energy strategy for 2030, predicts an increase of geothermal energy use, through direct production of the brine.
However, the direct mentioning of the well reuse and methods of well reuse are not that represented, other than in direct conversations with the regional or more often local representatives or with interested companies.

4. We are considering the reuse of wells as deep geothermal utilizations. Is there a depth defined in your country that marks the start for deep geothermal? Do you think the reuse of wells makes sense at shallower depth?

No, the depth is not the term to make distinction between deep and shallow geothermal. Rather it is usage of produced fluid directly in any energy systems (heating or generating electricity). According to the *Act on the Exploration and Production of Hydrocarbons (NN 52/18, 52/19, 30/21)* geothermal water is defined as: *Geothermal waters mean geothermal waters from which the accumulated heat can be used to generate energy, except for geothermal waters that are used for medicinal, balneological or recreational purposes and other purposes, and for which regulations on water apply (the Water Act and others), as well as underground water used via a heat pump for heating or cooling in the low-temperature heat distribution system, and to which construction regulations apply (the Construction Act and others).*
If the produced fluid is not directly used for thermal energy (for example heat pumps) then legislation should be followed according to the Water Act (NN 66/19, NN 84/21), Article 86, *the use of water is considered to be: 1. use of surface and underground waters, including spring, mineral and geothermal waters for various purposes (for drinking water supply, for placing on the market in original or processed form in bottles or other packaging, sanitary and technological needs, health and balneological needs, heating, irrigation and other purposes)*.

Yes, if there is a nearby user and the energy provided will cover its energy loads, provided the well is in a good condition to be revitalised.

Data, well ownership and well condition

Data in this sections concern the knowledge about the existence of wells – Availability, ownership, storage (How to find a well and its owner)

5. What industries are there in your country that use/need boreholes?

Agriculture, energy sector, aquaculture, drying processes (wood drying, fruit drying, etc.).

6. How many of these companies are operating in your country (Please separate between the industries if applicable)? How many wells are there in your country (give only an estimate)?

According to the The Croatian Bureau of Statistics, in December 2023, there were 2 875 active legal entities registered in agriculture, hunting, and forestry, around 122 000 registered family farming entities in various agricultural activities and around 350 agricultural cooperatives. For the same period there were total of 964 active legal entities registered in electricity, gas steam and hot water supply.

There are around 4000 wells in Croatia, but only around half of them are not liquidated.

7. If applicable: Are there any legal differences between these industries concerning the drilling of a well and the use of a well?
   Are there special permits necessary (please indicate the legal base)? Does this affect the reuse of a well? Please explain if yes.

No, there are no legal differences concerning the drilling or using the well when it comes to use in different industries.

Legal processes regarding obtaining the permits for drilling and use of wells are governed through the *Act on the Exploration and Production of Hydrocarbons (NN 52/18, 52/19, 30/21)* and corresponding acts and regulations.

8. Is there publicly available data on existing wells and what information does this data include (e.g. owner, production status, depth, age)? Please also explain if this data-base is complete for your country (are all wells that exists in this data-base) and if there are differences between the different industries if applicable.

Partially. According to the Act on the Exploration and Production of Hydrocarbons (NN 52/18, 52/19, 30/21), Article 122.: *All geological, geochemical, geotechnical, engineering and other data collected during exploration or exploitation, including all analyses, interpretations and studies based on these data are the exclusive property of the Republic of Croatia*. The well data is available according to the Ordinance on access to the data room and the use of data (NN 52/2023). Data on existing wells, which are not under active concession, is available for free if used for scientific purposes. Data used for developing a geothermal project can be accessed via data room in the Croatian Hydrocarbon Agency and is paid 50 EUR per one well,

for 2D seismic raw data it 5 EUR per km, 2D seismic processed data (stck/mig) is 10 EUR per km, 3D seismic raw data it 40 EUR per km^2, 3D seismic processed data is 80 EUR per km^2 .

There is some difference in the information available from each well, depending mostly on the year the well was drilled, i.e. the older the well it's more likely less data was collected at the time or if some exploration activities even took place. Most commonly the available data includes: well name, well abbreviation, depth, year of the drilling operations start and end, location, completion of the well, description of geological monitoring (depending on the field geologist descriptions have various levels of details) and well logging (also varies in detail and methods used). Usually, from the 70s onward the temperature at the bottom was measured, and from the 80s onward temperature data measured during the drill stem test (DST) can often be found.

9. Is there any information publicly available about the well conditions - is it still open, permanently or temporarily abandoned? Are there data available on the abandonment works? If yes have, how can they be accessible?

Same as previous - the data, if it exists, is available through the well database accessible in the data room in the Croatian Hydrocarbon Agency. For scientific purposes the access is free of charge, while for commercial use it is paid. For some of the wells the data of their current status is missing. Most of the wells have usually short document that says that the well was temporary or permanently abandoned, however most of them lack the documents describing the abandonment works.

10. Must the existence and status of a well be reported? If so, to whom?

Yes. All the data regarding the well has to be reported to the Ministry of Economy and Sustainable Development and to the Croatian Hydrocarbon Agency.

11. Who owns a well and its equipment? Is it the person who drilled the well, the state or someone else? (Please separate between the industries if applicable)

According to the Act on the Exploration and Production of Hydrocarbons and Article 115, the investor is the owner of all movable and immovable property during the licence/permit duration. After the exploration or exploitation operations are finished and the contract between the state and the investor is expired, all property within the exploration/exploitation area becomes the property of Republic of Croatia:

(1) Movable and immovable property acquired for the purpose of carrying out oil/gas and mining operations, which can be separated without causing damage to the permanent property, is the property of the investor who acquired the property, except when the value of that property reimbursed in the cost recovery process based on the exploration and division contract exploitation of hydrocarbons, in which case the Republic of Croatia acquires ownership of that property.

(2) The right of ownership of movable and immovable property becomes the property of the Republic of Croatia at the moment termination of contracts on exploration and hydrocarbon exploitation, regardless of whether they have been returned to the investor through property costs in accordance with tax regulations.

(3) In cases of cancellation or expiration of exploration permit, exploitation licence or expiration or termination of the contract on the exploration and exploitation of hydrocarbons, contract on the exploitation of geothermal waters, contract on underground gas storage, regardless of the reasons for cancellation or termination, expiration or termination on any basis of the existing right to exploitation, any immovable property or construction inseparable from the property in the exploration area or in the exploitation field *becomes the property of the Republic of Croatia*, regardless of whether the costs for such assets were reimbursed during the duration of the legal basis for the exploration or exploitation of hydrocarbons or geothermal waters, underground gas storage or the existing right to exploitation, and at the same time with the termination of the legal basis for the use of the oil/gas-mining facility, all rights and claims of the investor are terminated, which he had or could have considering his own investments in that oil/gas-mining facility.

12. Is the land, where surface facilities are placed mostly leased or company-owned?

This depends on the contract between the company and the owner of the land.

If the land is state owned, the state will ensure the land use through the respective body (depending on the use of the land - forests, agricultural etc.), with payment for the land use according to the Act regulating the use of the state owned land.

This is regulated with the Act on the Exploration and Production of Hydrocarbons, in Article 114:

(1) In accordance with the issued permit for the exploration and exploitation of hydrocarbons and the contract concluded on exploration and exploitation of hydrocarbons or a permit for the exploration of geothermal waters or …, if any land within the exploration area is owned by the Republic of Croatia, the central body of state administration responsible for management of state property, i.e. the body responsible for forestry or agricultural land, within 60 days from the day of receipt of the formal request on the part of the investor, passes the appropriate acts authorizing the investor to use the land within the framework without hindrance within the coordinates defined in the permit for the exploration and exploitation of hydrocarbons or the permit for geothermal exploration water or a …and gives the written consent of the property owner, which enables the investor obtaining the necessary permits.

(2) If the land referred to in paragraph 1 of this article is not owned by the Republic of Croatia, but is owned by third parties, investor, within the framework of the operations defined in the permit for the exploration and exploitation of hydrocarbons and the contract on exploration and exploitation of hydrocarbons or a permit for the exploration of geothermal waters or a…, in an appropriate manner arranges relations with land owners in order to be able to exercise all rights from the issued permit on such land exploration and exploitation of hydrocarbons and concluded contracts on exploration and exploitation of hydrocarbons or permits for the exploration of geothermal waters or the exploration permit for the purpose of natural gas storage or the permit for research for the purpose of permanent disposal of carbon dioxide. If the investor failed to resolve within three months property law relations, he is obliged to report this to the Agency

without delay and initiate actions for expropriation of land parcels in accordance with the provisions of the regulations governing the expropriation of real estate.

13. Are there regulations on how to deal with wells that are not used for the intended purpose or are no longer used? If so, what is the legal basis for this?

Generally, the exploration field or exploitation field along with the respective equipment (surface equipment, piping, well etc.) has to be restored/rehabilitated in such a manner that it is given its primary appearance and purpose, as best as possible (the closest to its original state as possible), in accordance with the Act on the Exploration and Production of Hydrocarbons and the restoration plan described in the main project. The investor has the obligation and has to fund the return of the exploration/exploitation area to its original state after the operations are ceased. In case the investor/company does not fulfill its obligation, the Agency will proceed with the restoration with the insurance fund provided by the investor.

14. What is the common timeframe for well abandonment since production stop?

According to the Act on the Exploration and Production of Hydrocarbons, if the temporary disruption of the oil/gas-mining operations is longer than 180 consecutive days (excluding force majeure), it is considered that the investor has completely and permanently suspended all oil/gas-mining operations within the exploitation field.

15. Is there any procedure the abandonment is tackled today?

According to the Act on the Exploration and Production of Hydrocarbons (NN 52/18, 52/19, 30/21), Article 122:

1) After the completion of oil/gas-mining operations, the investor is obliged to restore/rehabilitate the exploration area or exploitation field in accordance with this Act, special regulations related to the protection of the environment and nature, safety of people and property, protection of people's health, as well as international good practice in hydrocarbon and mining operations and to report this to the mining and environmental inspection.
2) If the oil/gas-mining inspection and environmental protection inspection determine that remediation has been carried out and that insurance measures, nature and environmental protection measures, as well as sufficient remediation, will be issued to the investor about this confirmation and report it to the Ministry and the Agency.
3) If the oil/gas-mining inspection and the environmental protection inspection establish that the rehabilitation and security measures from paragraph 2 of this article are not sufficient, it will order to the investor to remove within a certain period, not longer than six months, established deficiencies in the exploration area or exploitation field, and if necessary to implement other measures of insurance and notify the Ministry, the Agency and the central state administration body responsible for maritime affairs, if oil/gas-mining operations are carried out on the maritime domain.

4) If the investor does not act according to the order from paragraph 3 of this article, the inspections will report this to the Ministry and the Agency, and the Agency will implement the necessary insurance measures and rehabilitation at the expense of the investor.
5) The investor is obliged to pay all fees in accordance with this Act and the regulations adopted on the basis thereof of the Act on the exploration area or exploitation field before leaving the exploration area or exploitation field.
6) After receiving the confirmation from paragraph 2 and proof of fulfilment of obligations from paragraph 5 of this article, the Ministry will pass a decision on the deletion of an exploitation field from the register of exploitation fields, unless the commission for determination of reserves determines that the reserves have not been used and that there is a possibility of further performance of oil/gas-mining operations.

16. How long can a well at least be kept shut-in or temporarily abandoned without production from legislative side? What does it need for (e.g. field development plan if other drilling locations are planned, production licence)?

According to the Act on the Exploration and Production of Hydrocarbons (NN 52/18, 52/19, 30/21), Article 50:

…an exploitation field is considered to be abandoned in one of the following cases:

- exploitation in the exploitation field ceases permanently or ceases for a continuous period of 18 months, except if such termination was due to force majeure, or

– at the end of the exploitation period.

17. Are there obligations to integrate (immediate) reuse of a well, if a project was not successful in terms of its planned purpose?

No.

18. Do you know if orphan wells exist in your country? How do you get this information?

Yes. All data regarding existing wells (active or orphan) are stored at the Croatian Hydrocarbon Agency and can be accessed via data room.

Data, possible uses and utilization

Data in this section concern the knowledge about information to define the usability of a well (geology, hydrogeology, reservoir stuff…)

19. Are there requirements to report drilling plans and well data after drilling to authorities in general? If yes, which information/data has to be provided?

Yes. According to the Act on Exploration and Exploitation of Hydrocarbons - Articles 122 and 123 the Ministry of economy and sustainable development issued the Guidelines for submitting data collected

during exploration and exploitation of hydrocarbons, geothermal waters for energy purposes, underground gas storage and permanent storage of carbon dioxide:

- All geological, geochemical, geophysical, engineering and other data collected during research or exploitation, including all analyses, interpretations and studies performed on the basis of these data are the exclusive property of the Republic of Croatia;
- The investor is obliged to submit data to the Croatian Hydrocarbon Agency within 60 days after the completion of data collection, i.e. the creation of analyses, interpretations, studies and results based on the collected data;
- The Ministry responsible for energy (*The Ministry of Environment and Energy*) is responsible for the collection, storage, processing and disposal of all data and results;
- Operational tasks for the collection, storage, processing and disposal of all data and results under the supervision of the Ministry responsible for energy are performed by the Hydrocarbon Agency;
- The Hydrocarbon Agency, in cooperation with the Croatian Geological Surveye, ensures the storage of copies of all data at the Croatian Geological Survey.

The types of geological, geochemical, geophysical, engineering data and results from the preceding Article 122 of the Act are, but are not limited to, the following:

1. geophysical data including, without limitation, seismic, gravimetric and magnetometric and other geophysical data obtained by magnetotelluric, geoelectrical, georadar, satellite and other measurements. The data refer to all originally recorded, processed, specially processed and reprocessed data and their derived results, analyzes and studies

2. data collected during reconnaissance or preliminary regional research

3. geochemical data that includes, without limitation, original data, maps of locations and all interpreted data of geochemical measurements with all information about exact locations and the Act on Exploration and Exploitation of Hydrocarbons applied by analytical methods and standards, including reference standards and presentations of the results of all tested samples and final studies

4. well data which includes, without limitation, projects, original and interpreted data collected during well construction and data obtained with well logging and their final results and all reports, analyzes and all derivatives derived from them. The data refer to all geological, geophysical, geochemical and engineering data in original, processed and interpreted form

5. data on hydrocarbon production, geothermal waters, gas from underground gas storages and data on permanent storage of carbon dioxide

6. physical data including, without limitation, all cores, side cores, debris samples taken from the sieve, and fluid samples taken during well drilling and completion (the investor has the right to keep a reasonable part of samples of fragments and cores and fluids necessary for his own research)

7. reports, daily reports on oil/gas and mining operations, interpretations, analyses, presentations, elaborations and studies compiled on the basis of data collected during exploration or exploitation.

Daily reports on drilling, logging, testing and similar are given to the Agency on a daily basis in one of the following format: docx, .pdf, .xlsx or via an email, either immediately after the work is done or the next morning.

The well data are given in one of the following format: ascii (.las) or .pdf via either USB, external hard drive or ftp server within the 60 days of drilling a well.

20. Is this data or parts of it publicly available for free or at least partly free?

It is partly free. It is free for academic and research use.

21. Who is data owner of raw data (well data, log data etc.)?

The Republic of Croatia is the owner of the raw data. Act on the Exploration and Production of Hydrocarbons (NN 52/18, 52/19, 30/21), Article 122:

All geological, geochemical, geotechnical, engineering and other data collected during exploration or exploitation, including all analyses, interpretations and studies based on these data are the exclusive property of the Republic of Croatia.

22. Who is data owner of data interpretations (based on this well data or seismic data)?

The Republic of Croatia is the owner of the data interpretations.

Act on the Exploration and Production of Hydrocarbons (NN 52/18, 52/19, 30/21), Article 122:

All geological, geochemical, geotechnical, engineering and other data collected during exploration or exploitation, including all analyses, interpretations and studies based on these data are the exclusive property of the Republic of Croatia.

23. What is the attitude of companies/authorities regarding to provide data from wells or to make well data available to the public? Do have any experiences with this?

It is rarely the case that companies/authorities will provide in any case of data to the public. It is considered to be a business secret which can not be disclosed to the public.

24. Where are well databases stored (at commercial company, administrate organisation, authorities, universities and/or others as e.g. web maps, web services)? Please list them with references.

The well database is stored at the state owned Croatian Hydrocarbon Agency and can be accessed in the *data room*. The access is free for research purposes and potential investors have to pay per the price list. The map with active geothermal exploration and exploitation licences is available at: https://gis.azu.hr/portal/apps/webappviewer/index.html?id=03cd4f34c7254d83ac07a207385a8b91

By default, layers of Protected Areas (Strict reservations, Special reservations and National parks and Nature parks) are visible, but can be turned off, as well as Boundaries (Republic of Croatia and Continental shelf. Initially, regional (county) and municipal borders are turned off.

There is also an option to turn on the hydrocarbon exploration and exploitation location in the layers.

Also, according to the Act on the Exploration and Production of Hydrocarbon, all the data copies has to be stored additionally with the Croatian Geological Survey (https://www.hgi-cgs.hr/). According to the Act the Croatian Geological Survey institute must not provide access to third parties or use the data stored either for science or research without the written consent of the Croatian Hydrocarbon Agency.

25. List categories of well data, which are freely available for the public (at commercial company, administrate organisation, authorities, universities and/or others as e.g. web maps, web services).

The map with active geothermal and hydrocarbon exploration and exploitation licences is available at: https://gis.azu.hr/portal/apps/webappviewer/index.html?id=03cd4f34c7254d83ac07a207385a8b91

The data includes: field name, licence holder and area (in sq km).

In spring 2024, the CHA is expected to publish a unique interactive map of all exploration blocks and exploitation fields of geothermal water for energy purposes, selected well data and a map of the geothermal gradient in the Republic of Croatia that will be publicly available. The creation of the map, as well as the *The Deep Geothermal Energy Database* based on which the map is created, is financed by the EEA Financial Mechanism under the Energy and Climate Change Programme.

26. Estimate and describe in which formats most of the data is available. Is the data in digital formats, or is it scanned, in paper format or in another format (e.g. microfilm?).

Most of the data is currently available as scanned .pdf, scanned .tiff files and .las files.

27. Who is responsible for well integrity before establishing the recompletion for reuse?

This is the complete responsibility of the investor.

28. How does the ownership of a well can be changed? Is it a simple contract between two parties or are there any legal obligations to consider?

If a contract for the exploration/exploitation field property change (buyout), the Ministry and the Agency must be notified about the change. The investors are obligated to request a written consent from the Government, at the proposal of the Ministry. This is done according to the Article 34 : *Transfer of rights and obligations of the investor.* Transfer of rights and obligations can be partial or wholesome.

29. What are the requirements for the new owner/leasing (e.g. proof of capital)? Is a well owner change related to a change of production licences if applicable?

The licence and the contract is done for the exploration/exploitation field, not the wells themselves.

The investors are obligated to inform the Ministry, which informs the Government of the potential change. The Government is the body which can approve or reject such a request. Additionally, the Government has the right of priority to acquire a share in rights and obligations of the exploration and exploitation permit for hydrocarbons as well as the contract of exploration and exploitation of hydrocarbons. This is according to the Article 34 : *Transfer of rights and obligations of the investor* of the Act on the Exploration and Production of Hydrocarbons. Even though this Article refers to hydrocarbons, it is also valid in the case of exploration and exploitation of geothermal waters.

The investor must provide complete business plan with estimated capital costs and giving the bank guarantee of 10% amount as proof of seriousness.

30. Are obligations transferable to another owner/for lease? If yes, is it a common procedure?

The investors are obligated to inform the Ministry, which informs the Government of the potential change in ownership. The Government is the body which can approve or reject such a request. Additionally, the Government has the right of priority to acquire a share in rights and obligations of the exploration and exploitation permit for hydrocarbons as well as the contract of exploration and exploitation of hydrocarbons. This is according to the Article 34 : *Transfer of rights and obligations of the investor* of the Act on the Exploration and Production of Hydrocarbons. Even though this Article refers to hydrocarbons, it is also valid in the case of exploration and exploitation of geothermal waters.

It is not that common procedure.

31. Are there requirements of well integrity tests before and/or after recompletion (e.g. special surface equipment for possible hydrocarbon leakage)?

Legal framework, licensing/administration

This section focuses on regulatory approval for a well reuse. At this point, it should already be clear how the well will be used and what measures will be required (e.g. installation of tubing, drilling side tracks, extending the depth, productions tests…).

32. Resource – Does your country consider geothermal heat as a raw material? If yes, what is the legal base?

According to *Act on the Exploration and Production of Hydrocarbons (NN 52/18, 52/19, 30/21)* geothermal water is defined as: *Geothermal waters mean geothermal waters from which the accumulated heat can be used to generate energy, except for geothermal waters that are used for medicinal, balneological or recreational purposes and other purposes, and for which regulations on water apply (the Water Act and others), as well as underground water used via a heat pump for heating or cooling in the low-temperature heat distribution system, and to which construction regulations apply (the Construction Act and others).*

According to the Water Act (NN 66/19, NN 84/21), Article 86, *the use of water is considered to be: 1. use of surface and underground waters, including spring, mineral and geothermal waters for various purposes (for drinking water supply, for placing on the market in original or processed form in bottles or other packaging, sanitary and technological needs, health and balneological needs, heating, irrigation and other purposes)*.

33. Who owns the resource? Down to which depth?

The Republic of Croatia. The depth is not specified.

"Hydrocarbons, geothermal waters, geological structures suitable for natural gas storage and permanent disposal of carbon dioxide are owned by the Republic of Croatia."

34. Do you need an extra permit for workover? How is a recompletion handled? Is it different if the owner and the purpose of use change?

35. Please, briefly explain the legal basis for the approval of geothermal systems (consider the different application forms for geothermal energy e.g. deep BHE, pumping/reinjection well for HE) in general in your country. Which legal instruments apply and are they valid for a reuse? At which legislative levels are these regulations valid and executed (national level, regional level, local level)? Is the process comparable to that for a reuse? Please note differences between the reuse methods.

Currently, other than classic geothermal brine production, no other method of exploiting deep geothermal energy is not specified in the law (Act on the Exploration and Production of Hydrocarbons).

There is only a brief mention in Article 156:

8) Exceptionally, for the repurpose of wells, it is necessary to obtain a confirmation of the well project.

Other than this, the repurposing or reuse is not defined, especially not from the standpoint of different reuse methods.

36. What exactly needs to be approved for geothermal energy plants - the installation of the equipment and/or the energy generation? Concerning latter, is it the use of heat, the use of water or the influence to the environment/water for example?

37. Is there a difference in the licensing if you will produce heat or power?

No, when it comes to licensing of the exploitation field there is no difference. However, there is a difference on fees for production of heat and power. According to Ordinance on Fees for the Exploration and Production of Hydrocarbons (NN 25/20, NN 43/23) the fee for the exploitation of geothermal water consists

of two parts: 1. Fixed fee for the exploitation area and 2. Fee for produced geothermal water, as a variable element.

According to Article 11, the fixed fee for the exploitation area is 3.981,68 EUR/km², for facilities which produce mostly power (electricity) and 132,72 EUR/km² for facilities which produce mostly heat.

When it comes to the variable fee, it has to be minimum of 3% of market value of produced geothermal brine and it is calculated using the formula:

N_{var}= %×[(C_{el}×K_{el})+(C_{top}×K_{top})]

38. Are there different regulations for different depth levels?

The use of shallow geothermal energy via geoexchange system (closed loop) falls under the Act on simple constructions, while open loop systems fall under the Act on water.
The use of deep geothermal energy falls under the Act of the Exploration and Production of Hydrocarbons. Both is previously described.

39. Is there a difference in permitting concerning the different possibilities of reuse?

No, since the reuse methods are not recognized specifically in the Act.

40. Are there legal requirements for monitoring?

Yes.

41. What kind of permits or working plans is needed, if testing is needed?

42. How is the permitting procedure to drill a side-track or to expand the depth of an existing well? What are the legal requirements?

43. Are there specific environmental regulations in place for well reuse, and if so, what are they? Is there an obligation for an environmental impact analysis?

44. Do you know any reasons why a reuse or the recompletion is forbidden? (e.g. region was repurposed as environmental protection zone…)

No.

45. Which entities are involved in the licensing procedure?

The Ministry of Economy and Sustainable Development, Croatian Hydrocarbon Agency

46. Who is the authority to supervise the repurposing process of abandonment wells?

The Ministry of Economy and Sustainable Development, Croatian Hydrocarbon Agency

47. Is there a One-stop shop system for application (one responsible authority for the execution of a licencing procedure)?

No.

48. Is an online application possible?

No.

49. How long does a permission procedure take? Are there maximum time limits for procedures? Is there automatic permission after a deadline passed?

50. How long is a permit valid?

For the exploration operations the permit is approved for 5 years, with the possibility to extend 2 times, each time for 6 months. The exploitation permit (concession) and contract is awarded for 25 years, with the possibility of extension if the geothermal reservoir has such potential.

51. Is the permission related to special obligations during the installation and operation (e.g. reporting of production data)?

Yes.

Part 2 – Financial framework

The purpose of this questionnaire is to provide an overview of the financial framework for geothermal applications for reuse of existing wells.
Please note that reuse may require additional infrastructure compared to a conventional geothermal project because reuse is tied to existing sites. This means that heat exchangers or pipelines will be required to mitigate the reduced heat output.

Financial framework and funding

National funding

52. Is there national funding for geothermal applications based on reuse of existing wells? List the funding available. If yes, please name it, give a reference, purpose, and amount. Who is eligible for a given programme or funding source? If not, are there suitable alternative funding schemes, which can be used for this purpose?

In Croatia there are no, strictly, national funds that can be used for geothermal applications and projects with the aim of exploring and reusing existing wells. Instead, such projects are financed by alternative funding schemes, meaning a combination of European and Norwegian grants and national funding. The main competent authorities in Croatia for financing geothermal projects are the Ministry of Regional Development and Funds of the European Union and the Ministry of Economy and Sustainable Development.

Furthermore, the implementation of geothermal projects is recommended by the National recovery and resilience plan (NRRP), an operational program which provides guidance for application and implementation of projects that encourage energy efficiency, heating and renewable energy sources for decarbonization of the energy sector. Within the NRRP public Calls and Tenders for the financing of geothermal investment projects are announced. One of the latest Calls related to the geothermal topic was the following:

Preparation and research of geothermal potential in the context of centralized heating

Reference: https://fondovieu.gov.hr/pozivi/53

Purpose: The project investigates the geothermal potential for 6 smaller projects (in 6 areas located in the Pannonian part of Croatia). The funds are used to finance the assessment of geothermal potential, which includes the assessment of geothermal deposits where there is insufficient data to confirm the geothermal potential. Within agricultural and business zones, as well as existing heating systems, a geological – geophysical survey and study should analyse 9 locations (from which 6 areas would be selected to continue the investigative work). After the potential assessment, the two most promising areas would be singled out and one exploratory geothermal well would be drilled in each of them.

Amounts (under the last Call in 2023):

- Total grants: 29.862.631,89 EUR
- Minimum grant amount: 29.828.555,70 EUR
- Maximum grant amount: 29.862.631,89 EUR
- Co-financing rate: 100% of the total eligible costs

Eligible applicants: State administrative organisations (Croatian Hydrocarbon Agency (CHA))

The project Preparation and research of geothermal potential in the context of centralized heating is carried out in the following areas: City of Zagreb, Osječko – Baranjska County, Vukovarsko – Srijemska County and Sisačko – Moslavačka County. The project area includes the localities: Velika Gorica, Zaprešić, Osijek, Vukovar, Vinkovci and Sisak.

Apart from the mentioned, Croatia combines national funding and the Norway grants, more precisely the Financial Mechanism of the European Economic Area 2014 – 2021 (FMEEA). Within the mechanism, in the

past years, 4 Calls for Project Proposal submission have been published under the program "Energy and climate changes" and their main conditions are presented below.

Increasing capacity for geothermal energy production

Two Calls were open in the last 2 years: one regular in 2022 and one limited in 2023.

Reference: https://eeagrants.hr/izrada-tehnicke-dokumentacije-za-koristenje-geotermalne-energije-2-2/ ;

https://eeagrants.hr/objavljen-poziv-za-dodjelu-bespovratnih-sredstava-more-geoterma/ ;

https://eeagrants.hr/ograniceni-poziv-za-dodjelu-dodatnih-sredstava-more-geotermainvesticije/

Purpose: Development of pilot investments with the aim of increasing the capacity for the production and use of thermal energy obtained from geothermal energy. Some of the planned activities are: construction/revitalization of production and injection wells in areas with a valid permit for exploration and/or extraction of geothermal waters, renovation and/or extension of the heating system to geothermal energy, construction of infrastructure connections for the integration of geothermal heat into the existing heating systems, as well as technological and infrastructural changes of existing heating systems for the purpose of integrating geothermal energy sources.

Amounts:

- Under the regular Call in 2022:
  - Total grants: 4.956.000,00 EUR
  - Minimum grant amount: 200.000,00 EUR
  - Maximum grant amount: 1.300.000,00 EUR
  - Co-financing rate: from 60% to 85% (differs from case to case)
- Under the limited Call in 2023:
  - Total grants: 693.100,20 EUR
  - Minimum grant amount: 50.000,00 EUR
  - Maximum grant amount: 693.100,20 EUR
  - Co-financing rate: the same rates specified in the budgets for the items that need to be additionally financed

Eligible applicants: legal entities, public and private, commercial or non – commercial organisations and non-governmental organisations established as legal entities in the Croatia

Eligible partners: legal entities, public and private, commercial or non – commercial organisations and non-governmental organizations, established as legal entities in the donor countries (Norway, Iceland, Liechtenstein) or in Croatia.

The selected projects can be implemented on the continental territory of Croatia (Pannonia and Northern Croatia) according to the valid NUTS 2 classification. Additionally, bilateral cooperation activities can be implemented on the territory of the donor country.

Creating a database of deep geothermal energy

Reference: https://eeagrants.hr/izrada-baze-podataka-duboke-geotermalne-energije/

Purpose: Regarding geological properties and geothermal potential, Croatia can, generally, be divided into two areas: Pannonian Basin (area with the most potential in term of geothermal energy) and Dinarides (area with low potential of geothermal energy, but still underexplored). The Call supports projects, which plan to develop an online tool and database of deep geothermal energy to increase knowledge about the geothermal potential of deep sources in Croatia in order to advance the development of geothermal energy utilization projects. The online tool and database should be developed in the form of an interactive map within the Geographical Information System (GIS) and should contain relevant information about the wells, exploration areas and exploitation fields (such as name, geographic coordinates, depth, temperature gradient, status, number and type of testing, investors, duration permit(s) and other).

Amounts (under the last Call in 2022):

- Total grants: 200.000,00 EUR
- Minimum grant amount: 5.000,00 EUR
- Maximum grant amount: 200.000,00 EUR
- Co-financing rate: 100%

Eligible applicants: legal entities, public and private, commercial or non – commercial organisations and non-governmental organisations established as legal entities in Croatia

Eligible partners: legal entities, public and private, commercial or non – commercial organisations and non-governmental organizations, established as legal entities in the donor countries (Norway, Iceland, Liechtenstein) or in Croatia.

The selected projects can be implemented on the continental territory of Croatia. Additionally, bilateral cooperation activities can be implemented on the territory of the donor country.

Creation of technical documentation for the use of geothermal energy

Reference: https://eeagrants.hr/izrada-tehnicke-dokumentacije-za-koristenje-geotermalne-energije-2/

Purpose: Croatia has very favourable conditions for the use of renewable energy sources, whereby the geothermal potential is indicated by more than 25 natural thermal sources and proven by more than 4.000 deep wells drilled during the oil and natural gas exploitations. Most of the geothermal resources have a temperature in the range between 50 and 120°C, which enables the use of the geothermal energy for heating purposes. The Call supports project activities such as planning and development of technical documentation for the use of geothermal energy, project management and administration, as well as project promotion and increasing visibility.

Amounts (under the last Call in 2021):

- Total grants: 3.000.000,00 EUR
- Minimum grant amount: 200.000,00 EUR

- Maximum grant amount: 1.300.000,00 EUR
- Co-financing rate: from 50% to 85% (differs from case to case)

Eligible applicants: legal entities, public and private, commercial or non – commercial organisations and non-governmental organisations established as legal entities in Croatia

Eligible partners: legal entities, public and private, commercial or non – commercial organisations and non-governmental organizations, established as legal entities in the donor countries (Norway, Iceland, Liechtenstein) or in Croatia.

The area of implementation of the activities is limited to the continental area of Croatia (Pannonian Basin and its peripheral area). Additionally, bilateral cooperation activities can be implemented on the territory of the donor country.

53. Which are the typical timeframes for funding? Which types of the project they are covering (e.g. feasibility process, installation, operational phase). What are the requirements for funding?

The required characteristics of each funding Call listed in the previous question are presented below:

Preparation and research of geothermal potential in the context of centralized heating

Timeframes for funding: the last Call was open from 5th May to 25th May 2023 and the project implementation period is from 1st February 2020 to 30th June 2026

Types of projects:

- Preparation of a strategic study of the impact of the geothermal energy development plan on the environment
- Creation of a geological – geophysical study for geophysical data recording projects
- Preparation of a study of the situation in the area and changes of the spatial planning regulations
- Recording and interpretation of geophysical data and preparing a study of the geothermal potential
- Creation of exploratory wells

Requirements for funding:

Only the Croatian Hydrocarbon Agency (CHA) can be an eligible applicant. The Project Proposal must be submitted in Croatian language and contain the mandatory documentation listed in the Call.

Increasing capacity for geothermal energy production

Timeframes for funding:

- The regular Call in 2022 was open from 29th November 2021 to 28th January 2022. The planned duration of the project implementation is from 12 to 24 months.
- The limited Call in 2023 was open from 7th to 21st July 2023

Types of projects:

- Increasing the installed capacities for the production of geothermal energy
- Increasing the geothermal energy production and reducing annual CO_2 emissions
- Pilot projects related to: construction or revitalization of production and injection wells in areas with a valid permit, renewal and/or extension of the heating system to geothermal energy, construction of infrastructure connections for the integration of geothermal heat into the existing heating system, technological and infrastructural changes of the existing heating systems in order to integrate geothermal energy sources
- Project management and administration
- Project promotion and visibility.

The topics about project management and administration, as well as project promotion and visibility were not eligible for funding under the limited Call in 2023.

Requirements for funding:

- The regular Call in 2022:

Project Proposals must demonstrate contribution to the outcomes and direct results of the Program, mainly Outcome 2 “Increased production of energy from renewable sources” and direct Result 2.1 “Installed capacities for the use of energy from renewable sources”, as well as direct Result 2.2 “Strengthened capacities for management and promotion of renewable energy sources”.

The Project Proposal must be submitted in Croatian language (some parts of the Proposal and must be translated into English) and contain the mandatory documentation listed in the Call. Applicants can submit only one Project Proposal as Lead Partners and may participate in other Project Proposals as project partners. Additional criteria for applicants and project partners refer to their criminal and legal status (if they are convicted, bankrupt or in difficulty). The Call, also, provides an overview of acceptable and unacceptable costs within a particular Project Proposal.

- The limited Call in 2023:

The goal of the Limited Call is the allocation of additional grants to previously contracted projects within the Call for proposals “Increasing capacity for the production of geothermal energy” in order to achieve the expected results and indicators of the Program. Regarding this, the specific requirements for funding under this Call are:

- Proof that the additional grants are needed due to the increase in market prices, which the Lead Partner could not influence of foresee
- Additional grants will enable the project to complete its activities within the period of eligibility of costs
- The absorption capacity of the project based on the costs approved so far until the deadline for submitting the Proposal
- Contribution to the Program results.

The Project Proposal must contain the mandatory documentation listed in the Call.

Creating a database of deep geothermal energy

Timeframes for funding: the last Call in 2022 was open from 29th March to 27th May 2022. The planned duration of the project implementation is from 12 to 18 months.

Types of projects:

- Development of a database for storing all relevant data on deep geothermal energy in Croatia
- Development of an online interactive GIS map with a customized Graphical User Interface (GUI) that provides information from deep geothermal energy database datasets
- Project management and administration
- Project promotion and visibility

Requirements for funding:

Project Proposals must demonstrate contribution to the outcomes and direct results of the Program, mainly Outcome 2 "Increased production of energy from renewable sources" and direct Result 2.2 "Strengthened capacities for management and promotion of renewable energy sources".

The applicant must describe the details of the type of database that is planned to be used, its features and functionalities, as well as the potential to meet the required performance levels. Also, the applicant should present a reliable and simple GIS – based interactive graphical user interface solution, as well as develop technical user guidelines of the database and online tools for system administrators and other users.

The Project Proposal must be submitted in Croatian language (some parts of the Proposal and must be translated into English) and contain the mandatory documentation listed in the Call. Applicants can submit only one Project Proposal as Lead Partners and may participate in other Project Proposals as project partners. Additional criteria for applicants and project partners refer to their criminal and legal status (if they are convicted, bankrupt or in difficulty). The Call, also, provides an overview of acceptable and unacceptable costs within a particular Project Proposal.

Creation of technical documentation for the use of geothermal energy

Timeframes for funding: the last Call in 2021 was open from 14th September to 15th December 2021. The planned duration of the project implementation is from 12 to 24 months.

Types of projects:

- Preparation of technical documentation for geothermal energy (the created documentation will be used to increase geothermal energy production and reduce CO_2 emissions)
- Project management and administration
- Project promotion and visibility

Requirements for funding:

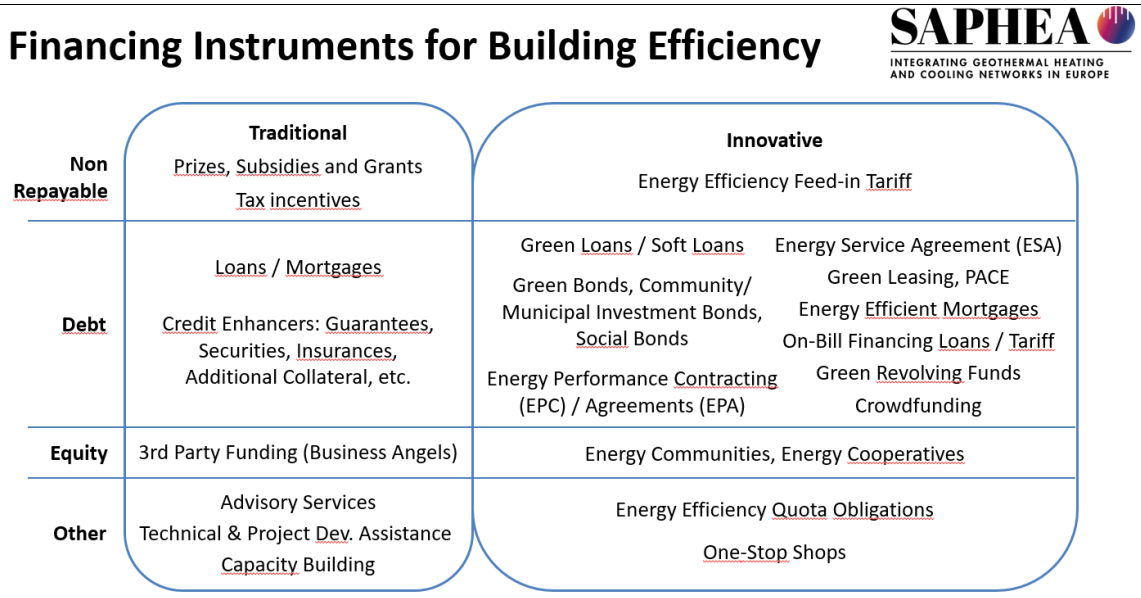
Project Proposals must demonstrate contribution to the outcomes and direct results of the Program, mainly Outcome 2 "Increased production of energy from renewable sources" and direct Result 2.1 "Installed

capacities for the use of energy from renewable sources", as well as direct Result 2.2 "Strengthened capacities for management and promotion of renewable energy sources".

The Project Proposal must be submitted in Croatian language (some parts of the Proposal and must be translated into English) and contain the mandatory documentation listed in the Call. Applicants can submit only one Project Proposal as Lead Partners and may participate in other Project Proposals as project partners. Additional criteria for applicants and project partners refer to their criminal and legal status (if they are convicted, bankrupt or in difficulty). The Call, also, provides an overview of acceptable and unacceptable costs within a particular Project Proposal.

Traditional and innovative financing options

54. Are there examples of financing options in your country listed in the Figure below? If so, please name and describe them.



From the traditional financing options, Croatia uses grants, subsidies and loans, mostly, from external financing programs and calls, as well as national banks. The mentioned are described in the previous and following questions.

Regarding the innovative financing options, Croatia has the possibility to use Energy Performance Contracting (ESCo) and crowdfunding, but in the field of electricity, not heating/cooling and not for geothermal sources. Other information about innovative financing options for exploring and use of geothermal potential in Croatia are not publicly available.

55. Are there any other financing options in your country or do you know about any other in general (e.g. can be an example from another country)?

Apart from the financing programs and Calls, Croatia uses several European support options, whose priority axes and objectives are related to energy efficiency, renewable energy sources, just transition and reduction of CO_2 emissions (decarbonisation), while at the same time, they encourage a strong cross – border and transnational cooperation among EU and non – EU states. Related to the mentioned, some of the most significant financing options applicable for Croatian green and energy projects, as well as their activities related to renewable energy sources (among others, also, geothermal) are:

Interreg Central Europe

Reference: https://www.interreg-central.eu/

Priority 2: Cooperating for a greener central Europe

Specific objective SO 2.1: Supporting the energy transition to a climate-neutral central Europe

Territories need to respond to the challenges of environmental degradation and climate changes by increase in efficient use of resources, protecting and restoring biodiversity, as well as cutting pollution. The program helps regions and cities to cooperate, develop and test solutions for a greener central Europe.

Actions/areas:

- Energy planning at local and regional levels
- Renewable energy sources
- Reduction of greenhouse gas emissions from industry and other sectors.

Interreg IPA Croatia – Bosnia and Herzegovina – Montenegro

Reference: https://interreg-hr-ba-me.eu/

Priority 2: Green investments in environmental protection and efficient risk management

Specific objective RSO2.1: Promoting energy efficiency and reducing greenhouse gas emissions

The program is focused on the effects in reducing energy consumption, the introduction of innovative technologies in the field of renewable energy sources, as well as supporting models and practices that raise the energy efficiency of buildings and households. The actions are focused on public infrastructure, creation of knowledge – bases and human resources required for energy transition, as well as national, regional and local agencies that promote energy efficiency and encourage end users to use energy from renewable sources, as well as rationalise the energy consumption.

Actions/areas:

- Promoting the production and use of advanced biofuels (produced from non – food crops, such as cellulosic biofuels, and biomass supplied from sustainable sources), as well as other renewable energy sources (e.g., solar, geothermal energy), prioritising the use of brownfield locations.

Innovation fund

Reference: https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund_en

An EU fund for climate policy focused on energy and industry, which aim to bring solutions to decarbonise the industry and support its transition to climate neutrality. The Fund is focused on highly innovative technologies and flagship projects that can bring significant emission reductions and aims to help businesses invest in clean energy and industry, boost economic growth, create future – proof jobs and reinforce technological leadership on a global scale.

Actions/areas:

- Innovative low – carbon technologies and processes in energy – intensive industries
- Carbon capture and utilisation
- Construction and operation of carbon capture and storage
- Innovative renewable energy generation
- Energy storage.

Modernisation Fund

Reference: https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/modernisation-fund_en

The fund supports the modernisation of energy systems and the improvement of energy efficiency in lower – income EU Member States. The financed projects include various activities in the fields of renewable energy, energy efficiency, storage and networks, as well as fair transitions in carbon – dependent regions.

Actions/areas:

- Generation and use of energy from renewable energy sources
- Heating and cooling from renewable energy sources
- Reduction of overall energy use through energy efficiency, including industry, transport, buildings, agriculture and waste
- Energy storage and modernisation of energy networks, including demand – side management, district heating, grids for electricity transmission and the increase of interconnections between member states
- Support for low – income households, including rural and remote areas, to address energy poverty and modernise their heating systems and infrastructure for zero – emission mobility
- Just transition in carbon – dependent regions to support redeployment, reskilling and upskilling of workers, education, job-seeking initiatives and start – ups.

Other incentives

56. Are there any financial incentives for companies to locate in regions where abandoned wells are situated? If yes, please give a short description.

Since the Croatian geothermal potential is still, mostly, in an exploration phase, there are no financial incentives which would support the companies (large and SME) to locate in regions with geothermal energy sources.

For now, the only activities that are funded are exploration of abandoned wells and regions with geothermal potential and renewable energy use in order to increase energy efficiency. Regarding this, the Ministry of Regional Development and EU Funds, the Ministry of Economy and Sustainable Development, the Environmental Protection and Energy Efficiency Fund, the Croatian Bank for Reconstruction and Development, as well as some regional and local governments publish calls, approve grants, credits and loans to stimulate the entrepreneurship sector to turn to energy efficient business.

Some of the activities that are financed with the mentioned financial options are:

- Initial investments in assets for the introduction of new technologies and technological solutions resulting in more efficient use of resources and/or reduction of energy consumption and/or reduction of CO_2 emissions
- Improvement/modernisation of the existing heating/cooling and other energy production systems
- Installation of new heating/cooling and other energy production systems
- Installation of systems and equipment that uses renewable energy sources
- Preparation of the technical documentation needed for energy efficiency projects
- Energy audits for SME's.

57. Does development or strategic planning for regions with abandoned wells exist?

As Croatia turns more and more to renewable energy sources and strives to become an energy efficient and neutral country, it adopted several strategic documents that plan and regulate the use of unconventional energy sources.

Regarding the mentioned, the main documents in national level are:

- Energy development strategy of the Republic of Croatia until 2030 with a look at 2050
- Plan for the development of geothermal potential of the Republic of Croatia until 2030
- National energy efficiency action plan for the period from 2022 to 2024
- Integrated national energy and climate plan for the Republic of Croatia for the period from 2021 to 2030.

Also, each county in Croatia draws up its own strategy or plan with detailed development areas and potential projects, among other, in the field of energetics and energy production (this includes project regarding the use of geothermal energy for counties with such potential).

Appendix 5 - Questionnaire Austria

Author and country update on well reuse

Author	Doris Rupprecht, Monika Hölzel
Organisation	GeoSphere Austria
Country	Austria
Contact	monika.hoelzel@geosphere.at

Executed projects: Do reuse projects exist in your country? If yes, please indicate the name, starting date, approximate duration of use, project partners and a short description.

Deep Borehole Heat Exchanger

Prottes T 11

Reuse of an oil producing well in the Vienna Basin (Weinviertel). The well was drilled in 1974 with a total depth of 2980. The used interval for DBHE equipment was 0 - 2243 m with a bottom hole temperature of 83°C. Before re-completion a pressure test for well integrity was undertaken. The project was running from 2009 – 2011 and operated by OMV AG. The heat costumer was the municipality of Prottes, where a sport hall was heated.

Project report (in german): https://www.klimafonds.gv.at/wp-content/uploads/sites/16/BGR0262011EE_Geothermie.pdf

Neukirchen a.d. Vöckla (Mühlleiten-002)

Reuse of an uneconomic gas well in the Molasse Basin, started in 2012 and is shut-in recently. The well was drilled in with a total depth of 2850 m with a temperature of 105 °C. Operator is RAG Austria and the heat is delivered 1 km via pipeline to Bioenergie Neukirchen for communal heating.

Press release (in german): https://www.ots.at/presseaussendung/OTS_20120503_OTS0111/einzigartiges-regionales-energie-projekt-aus-einer-kombination-von-erdwaerme-und-biomasse-fuer-neukirchen-ad-voeckla-eroeffnet

At least one HC well in the Styrian basin is reused as water injector of a hydrothermal system (Blumau 1/1a). Other dry hydrocarbon wells were used as references for hydrothermal or balneological wells.

1. Do you have information about the procedure for reuse of wells and about learnings from practice? If so, please describe them.

For the reuse of wells as DBHE (Prottes T 11 and Neukirchen ML-002) we have no detailed information about the procedure. Prottes T 11 was declared as 3-year research project. As it has been a depleted oil producer, a pressure test for well integrity before recompletion was obliged from the mining authority.

Neukirchen (ML-002) was a dry well. Both projects have in common that the well operator stayed the responsible in the projects.

From a rejected DBHE project there is information that the recompletion procedure does not need special requirements. But even it was a cased dry well a HiLo Safety Valve had to be installed which automatically prevents gas spills. The other surface applications and economical rezoning of the surface location are very long lasting (pers. comm.).

2. Are there reuse projects in the planning phase? If yes, please indicate the name and maybe a short description.

There was one DBHE project recently in the planning phase but due to the withdrawal of the user (aquaculture) the project was stopped (pers. comm. 02-2024).

3. Is the reuse of wells a political topic in your country? E.g., do national, regional or local energy plans mention well reuse? Do companies/others show interest in well reuse?

No known political interests. But the topic is known. In the KPC funding program, the reuse of old boreholes is designated as a separate funding point**.**

Company interests

In the 2010s years, reuse projects as deep geothermal heat exchangers were executed by the two major oil and gas companies in Austria. The projects did not meet expectations for various reasons (rapid temperature drop during operation, leaking tubing).). One of them was planned as a scientific project for 3 years.

In the Styrian Basin former dry hydrocarbon wells are in use for water injection of geothermal installations (e.g. Blumau 1/1a operated by RAG Austria). In the 1980s, the HC industry was not interested in these wells.

There are companies that would realise reuse for their business model: e.g. Greenwell Energy

4. We are considering the reuse of wells as deep geothermal utilizations. Is there a depth defined in your country that marks the start for deep geothermal? Do you think the reuse of wells makes sense at shallower depth?

No definition of depth available. However, due to the legal framework (involvement of the mining authority from a drilling depth of 300 m), the limit of 300 m for shallow geothermal energy has been established. Deep geothermal energy is understood to begin at around 2000 m. Most systems in Austria go below this

depth. In between, one rarely speaks of medium-deep geothermal energy. There are no known facilities for this in Austria.

Data, well ownership and well condition

Data in this sections concern the knowledge about the existence of wells – Availability, ownership, storage (How to find a well and its owner)

5. What industries are there in your country that use/need boreholes? (Which depth?)

Oil and gas industry (Boreholes up to 8000 m)
- Fuels
- Energy
- Chemical industry

Agriculture (Boreholes up to 3500 m)
- Green house heating; e.g. Frutura)

Medical (Boreholes up to 3500 m)
- Balneology, Thermal spa

Food (Boreholes up to 300 m)
- Mineral water (e.g. Römerquelle: 80-250 m)

Infrastructure (BBT up to 720 m)
- tunnel construction (e.g. large railway tunnel projects)

Academia
- e.g. University Vienna, well Sooß Vienna Basin

6. How many of these companies are operating in your country (Please separate between the industries if applicable)? How many wells are there in your country (give only an estimate)?

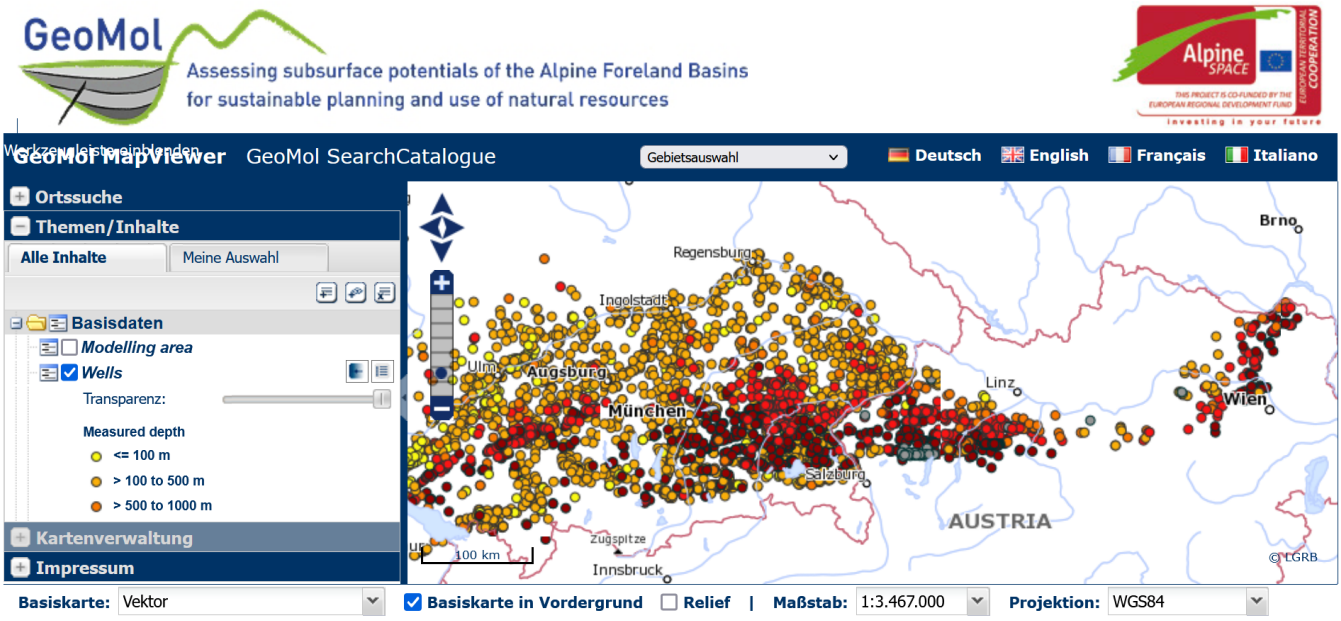
Industry	**operators**	**number of wells total**
Oil and gas industry	3	7000
Agriculture	2	5
Medical	2	20
Food	~15	10
Infrastructure	3 big tunnel projects (> 20 km)	9 +
Academia	1 known	1

7. If applicable: Are there any legal differences between these industries concerning the drilling of a well and the use of a well?
   Are there special permits necessary (please indicate the legal base)? Does this affect the reuse of a well? Please explain if yes.

For the drilling a well deeper than 300 m there are the same regulations for hydrocarbons, water or heat.
These regulations are based on MinroG (Mineralrohstoffgesetz).
The use for geothermal purposes is also regulated based on the water act (Wasserrechtsgesetzt WRG 1959).

8. Is there publicly available data on existing wells and what information does this data include (e.g. owner, production status, depth, age)? Please also explain if this data-base is complete for your country (are all wells that exists in this data-base) and if there are differences between the different industries if applicable.

There are no complete well datasets (> 300 m depth) for the country publicly available.
There are:
https://www.geomol.eu/home/index_html



This map viewer included well locations in Austria in the Molasse and Vienna Basin with depth categories. In this map viewer temperature and other maps are included.
The Geothermal Atlas of Austria is under development:
https://www.geologie.ac.at/en/research-development/mapping/energy/geothermal-energy-1
Other sources of well information are scientific papers and other publications (e.g. Supplements of the Geological Map of Austria: https://www.geologie.ac.at/onlineshop/textpublikationen/erlaeuterungen)

9. Is there any information publicly available about the well conditions - is it still open, permanently or temporarily abandoned? Are there data available on the abandonment works? If yes, how can they be accessible?

There is no public information about well status or planned abandonments.
There is a publication of the mining Authority (Montanhandbuch; https://www.bmf.gv.at/themen/bergbau/publikationen.html), which includes statistics about HC wells in operation.

Tabelle 19 Gewinnung, Erzeugung, Betriebsstätten und Belegschaft im Erdöl- und Erdgasbergbau im Jahr 2022

number of companies	production oil		gas		oil wells producing	gas wells producing	number of employees	workers
Erdöl-Erdgas-Bergbau-unternehmungen	Erdöl in t	Natur-gas[1] in 1.000 Nm³[*]	Neben-produkt NGL [1][2]	Neben-produkt Schwefel in t	förd. Erdöl-sonden[3]	förd. Erdgas-sonden[3]	beschäftigte Personen[4]	davon Arbeiter
3	521.211	607.131	11.128	4.672	569	106	688	200

Quelle: [1]BMF, Abt. VI/6
[2]Kondensat + LPG (Liquified Petroleum Gas)
[3]Dezember 2022 je Tubingstrang
[4]ohne Beschäftigte der Zentrale
[*]Normkubikmeter (Volumen von 1 m³ Gas bei 1,01325 bar und 0 °C)

10. Must the existence and status of a well be reported? If so, to whom?

Wells deeper than 300 m need an approval from the Mining Authority (Ministry of Finance).

> This is based on MinroG (Mineralrohstoffgesetz): § 119. (1) Authorisation must be obtained from the authorities for the construction of surface mining facilities and tunnels, shafts, boreholes with wells from a depth of 300 m and probes from a depth of 300 m serving mining purposes.

With 1.1.2023 companies are obligated to report directly the start of drilling projects deeper than 50 m at least 2 weeks before spud to GeoSphere Austria (Geological Survey of Austria).

> This is based on law MinroG (Mineralrohstoffgesetz): Inkrafttreten (42) § 31, § 38, § 58 Abs. 3, § 59 Abs. 2, § 65 Abs. 3, § 77, § 93 sowie § 190 Abs. 3 in der Fassung des GeoSphere Austria-Errichtungsgesetzes, BGBl. I Nr. 60/2022, treten mit 1. Jänner 2023 in Kraft.)

11. Who owns a well and its equipment? Is it the person who drilled the well, the state or someone else? (Please separate between the industries if applicable)

The well owner is the person/company who applies for permits for the borehole from the mining authorities (Bergbauberechtigter).

12. Is the land, where surface facilities are placed mostly leased or company-owned?

MinroG (Mineralrohstoffgesetz)

§ 147 Before using the surface and the area near the surface of another person's land or parts thereof for the purpose of carrying out the activities specified in section 2 (1), the authorised miner shall obtain the consent of the landowner.

§ 148. (1) If the landowner consents to the use of his property or a part thereof in return for appropriate compensation, but no agreement is reached with the person authorised to mine, either party may apply to the authority for the determination of such compensation.

For hydrocarbon drillings und production facilities mostly the land is leased. For hydrothermal projects, it is rather common that land is owned.

13. Are there regulations on how to deal with wells that are not used for the intended purpose or are no longer used? If so, what is the legal basis for this?

see below

14. What is the common timeframe for well abandonment since production stop?

To give a timeframe can vary form well to well. If a company could make evident that a well should kept in for further field development, a well could be held shut in for c. 10 years. If a well is considered uneconomic and without a production licence, the abandonment can follow the logging/testing phase (< 1 month).

15. Is there any procedure the abandonment is tackled today?

Borehole Mining Regulation § 53 (Bohrlochbergbau-Verordnung)
(1) Depleted boreholes and borehole-parts as well as boreholes that are no longer in use must be backfilled in a gas- and liquid-tight manner in accordance with the state of the art. Permeable horizons that have been drilled through must be sealed in such a way as to prevent the migration of gaseous or liquid media and adverse effects on groundwater and the surface.
(2) The intended backfilling of the borehole shall be notified to the authority at least four weeks before the work is carried out, together with the presentation of the borehole image (longitudinal section) and a backfilling plan.

This notification must include information on the following points:

1. reason for the backfilling;
2. setting levels of the casing and position of the cementation sections;
3. pressure conditions in the individual annular spaces;
4. type and quantity of the pumped or discharged media;
5. pressure conditions in open permeable horizons;
6. areas with hydrocarbon lines or measured groundwater horizons as well as other safety-relevant areas;
7. information on the installation of pipework;
8. planned backfill materials and backfill sections as well as the location of mechanical seals; and
9. type and duration of the measures by which it can be demonstrated after the backfilling work has been carried out that no migration of gaseous or liquid media and no detrimental effects on groundwater and the surface are to be expected.

(3) The authority must be notified of the backfilling work carried out within three months, together with a current borehole image.

16. How long can a well at least be kept shut-in or temporarily abandoned without production from legislative side? What does it need for (e.g. field development plan if other drilling locations are planned, production licence)?

At least an active production licence is required to keep a well-shut in based on Mineralrohstoffgesetz (MinroG): The time frame is dependent on the working plan of the licence.
§ 78. The commencement, any interruption lasting longer than six months and the resumption of the extraction of federally owned mineral resources or the storage of liquid or gaseous hydrocarbons in an extraction field shall be notified to the authority without delay. If extraction or storage is interrupted, the expected duration of the interruption must also be stated.

17. Are there obligations to integrate (immediate) reuse of a well, if a project was not successful in terms of its planned purpose?

There are no obligations from the authority for reuse in case of an unsuccessful drilling project.
For funding, there is a requirement to create concepts for drilling that is not well-found or partially well-found (e.g. KPC). However, subsequent use is not required. It also should not be checked before drilling is shut down.

18. Do you know if orphan wells exist in your country? How do you get this information?

There are no orphan wells in Austria since WWII (From 1939-45 for some projects it is not sure if they were realised or not).

Data, possible uses and utilization

Data in this section concern the knowledge about information to define the usability of a well (geology, hydrogeology, reservoir stuff…)

19. Are there requirements to report drilling plans and well data after drilling to authorities in general? If yes, which information/data has to be provided?

There is the obligation to report to the Mining Authority about well results (based on Bohrlochverordnung):

§ 40 The petrographic and geological nature of the drilled strata must be continuously determined. Records must be kept of this.

Borehole image

§ 40a. The mining licence holder shall prepare and keep up to date a borehole log (longitudinal section) for each borehole, which shall show the following:

1. the name of the borehole,

2. The coordinates […],

3. the purpose of the borehole,

4. the time of the start and end of the drilling,

5. the full length of the borehole in terms of inclination and direction (azimuth),

6. the depth, petrographic and geological nature, composition and thickness of the drilled rock strata,

7. the borehole diameters as well as the diameter and setting level of the casing,

8. the location of the cementation and perforation sections,

9. the areas with water inflows, losses of circulation media, oil or gas indications as well as other safety-relevant areas,

10. the time and type of backfilling.

The GeoSphere Austria has the right to request data from operators to perform its duties to the state. https://www.ris.bka.gv.at/Dokumente/BgblAuth/BGBLA_2022_I_60/BGBLA_2022_I_60.pdfsig. Valid for data gathered from 1.1.2023 (§ 12. Datenbereitstellungspflicht = Data provision obligation)

Data is restricted for internal use only. Companies are obligated to provide them on request. No automatic report is required.

20. Is this data or parts of it publicly available for free or at least partly free?

Data is property of the company and not available. The mining authority provides no information to the public (or natural or legal persons or partnerships under commercial law).

21. Who is data owner of raw data (well data, log data etc.)?

Raw data is owned by company.

22. Who is data owner of data interpretations (based on this well data or seismic data)?

For commercial projects, normally the client is the owner of interpreted data.
Otherwise defined, the interpreter is the owner of interpreted data.

23. What is the attitude of companies/authorities regarding to provide data from wells or to make well data available to the public? Do have any experiences with this?

Oil and gas companies have no interest in releasing their data. They see it as an asset. One listed company provides public interpretations of projects on its website (https://adx-energy.com/investor-centre/asx-announcements/).
The mining authority does not provide well data. There is only the obligation (based on MinroG § 185: https://www.bmf.gv.at/themen/bergbau/digitalisierung-im-bergbau/bergbauinformationssystem.html) to publish information on Exploration areas, Mining authorisations, Federal mineral resources, Extraction operation plans and Exploration authorisations (BerGIS: https://bergis.rmdatacloud.com/Start)

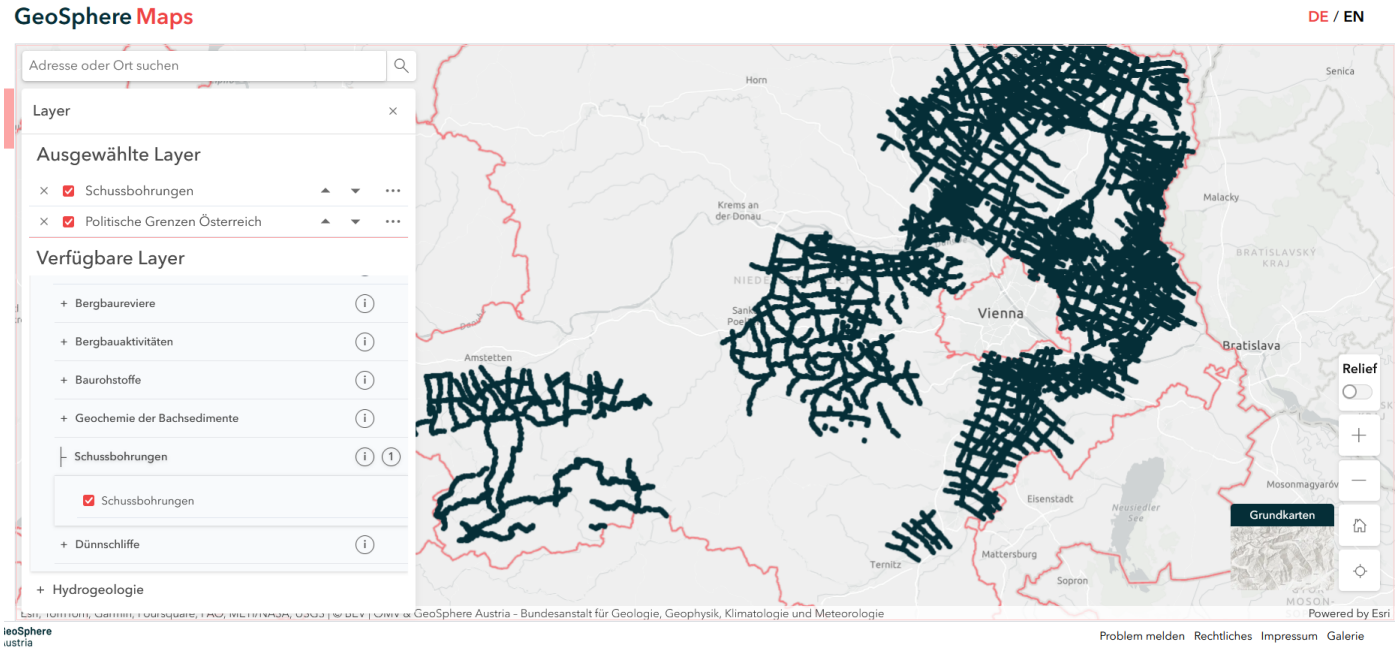
24. Where are well databases stored (at commercial company, administrate organisation, authorities, universities and/or others as e.g. web maps, web services)? Please list them with references.

Borehole and subsurface data (of wells > 300 m) is stored in

- Company internal databases (OMV AG, RAG Austria, ADX Energy)
- GeoSphere Austria
- Ministry of Finance: Mining Authority (only applications, reports, administrative decisions)

25. List categories of well data, which are freely available for the public (at commercial company, administrate organisation, authorities, universities and/or others as e.g. web maps, web services).

- Drillings for seismic explosives (Schussbohrungen), Webmap GeoSphere Austria (https://maps.geosphere.at/de)
-



- Shallow wells (< 300 m) Austrian States (e.g. DORIS https://metadaten.doris.at/geoportal_extern/catalog/search/browse/browse.page)

26. Estimate and describe in which formats most of the data is available. Is the data in digital formats, or is it scanned, in paper format or in another format (e.g. microfilm?).

In HC companies most of the data (est. 70% is available pure digital format). From ancient field data could be available as scans. Older seismic data could be still stored in microfilms.
In public databases basic well data is available fully digital, detail data like logs, well paths, production is mostly available in scans.
Generally the grade of digitalisation together with a good structured and categorised (e.g. well markers) well data base should be improved within companies and public organisations.

27. Who is responsible for well integrity before establishing the recompletion for reuse?

The well owner with mining authorisation (Bergbaubefugnis; MinroG).

28. How does the ownership of a well can be changed? Is it a simple contract between two parties or are there any legal obligations to consider?

see answer 25

29. What are the requirements for the new owner/leasing (e.g. proof of capital)? Is a well owner change related to a change of production licences if applicable?

A change in well ownership requires a change in the (production-) licence holder (Bergbauberechtigter – authorised miner). The requirements for this are based on Minrog § 84: (1) The holder of an approved extraction plan (sections 83 and 116) for the extraction of mineral resources shall be deemed to be a person authorised to mine. (2) A change of the holder of an authorised extraction plan shall be notified to the authority and evidence thereof provided. (3) An approved extraction plan shall expire upon the expiry of a time limit set, upon the demise of the legal entity, unless universal succession occurs, by declaration to the authority that it is resigned, by withdrawal pursuant to section 193(9) or by the expiry of the right granted by the landowner to the holder of the approved extraction plan within the meaning of section 83(3). The expiry of the extraction plan shall not affect the obligations imposed by this Federal Act on the authorised miner. These obligations shall apply to the last holder of the mining operations plan. The official orders shall also be issued to the latter. How liabilities are transferred is not regulated, so companies do not sell wells, only assets with companies in a package).

30. Are obligations transferable to another owner/for lease? If yes, is it a common procedure?

See answer above. For single wells there is no procedure.

31. Are there requirements of well integrity tests before and/or after recompletion (e.g. special surface equipment for possible hydrocarbon leakage)?

The mining authority decides from case to case.

Legal framework, licensing/administration

This section focuses on regulatory approval for a well reuse. At this point, it should already be clear how the well will be used and what measures will be required (e.g. installation of tubing, drilling side tracks, extending the depth, productions tests…).

32. Resource – Does your country consider geothermal heat as a raw material? If yes, what is the legal base?

No, geothermal heat is not considered a raw material. The use is regulated by the MinroG (drilling activities > 300m) and is viewed there as a mining-like process. The use of water (directly through hydrothermal geothermal energy) or the influence on water (indirectly through deep probes) is regulated by water law.

33. Who owns the resource? Down to which depth?

Since heat is not a raw material, ownership of it is not regulated. Since water law applies to geothermal systems, the use and impairment of water must be approved. The rule here is that water belongs to the property owner up to the centre of the earth. In general, foreign law and public interests must be taken into account. This means that even if someone else's property is touched underground, the respective property owners have the right to object.

34. Do you need an extra permit for workover? How is a recompletion handled? Is it different if the owner and the purpose of use change?

35. Please, briefly explain the legal basis for the approval of geothermal systems (consider the different application forms for geothermal energy e.g. deep BHE, pumping/reinjection well for HE) in general in your country. Which legal instruments apply and are they valid for a reuse? At which legislative levels are these regulations valid and executed (national level, regional level, local level)? Is the process comparable to that for a reuse? Please note differences between the reuse methods.

36. What exactly needs to be approved for geothermal energy plants - the installation of the equipment and/or the energy generation? Concerning latter, is it the use of heat, the use of water or the influence to the environment/water for example?

Two main laws apply for the installation and use of geothermal energy.

1. Drilling/Installations: **Mining law (MinroG)**
   Geothermal energy is not mining – a mining-like process, a pure plant procedure on the part of the mining authority. The MinroG also applies to the reuse as soon as changes are made to the permit for the original borehole (e.g. side tracks).
   The legal wording is as follows (§2): "The search and research of geological structures of deposits of geothermal energy and the extraction of this energy (geothermal energy, heat use of water) insofar as tunnels, shafts or boreholes more than 300 m deep are created or used for this purpose".
   The production of boreholes (probes) deeper than 300 m requires a permit in accordance with § 119 MinroG - the provisions of the **Borehole Mining Ordinance** must be observed
2. Use of geothermal energy: As explained in question 28/29 the use of geothermal energy is regulated with the use of water. The applicable law is the Water Act (WRG 1959). The water act regulates:
   - The extraction if the Extraction exceeds domestic needs: approval requirement according to §10 WRG 1959
   - §§ 12 and 13 WRG 1959 – type and extent of water use must be determined – protection of public interests and existing rights
   - Existing rights: common water uses, rights of use according to §5 WRG 1959 and property ownership
   - Discharge of thermal water (§30 WRG 1959: to protect groundwater in such a way that a deterioration of the respective condition is prevented) requires a permit according to §32 WRG 1959 if the nature of the water in question is slightly impaired

- Temporary interventions (e.g. pumping tests) require a permit (§56 WRG 1959)
- §31c. Other precautions against water hazards: Paragraph 5b) "Systems for the production of geothermal heat in the form of vertical collectors (deep probes)"… "if they exceed a depth of 300 m".

The notification procedure according to §114 WRG 1959 can be applied to projects described in §31c. Otherwise, a "normal" approval procedure must be carried out

37. Is there a difference in the licensing if you will produce heat or power?

No, concerning the underground installations.

38. Are there different regulations for different depth levels?

The water act is always valid, the mining law for installation deeper than 300 m. Depending on the location and depth (applies more to deep drillings > 1000 m) of the facility, there is also the possibility of an environmental impact assessment (EIA). Regarding the latter, there is little experience in Austria and the legal regulations are not clear as geothermal energy is not mentioned. However, some aspects of the installation of geothermal systems may be subject to the provisions of law dealing with EIA. However, the interpretation of the legal matter often differs.

39. Is there a difference in permitting concerning the different possibilities of reuse?

The execution of the permit may differ if water is not moved but only touched (deep geothermal probe). A simplified procedure could also be used here (depending on the interpretation of the legal matter). However, there are no examples of this in Austria.

40. Are there legal requirements for monitoring?

There is no fixed procedure. The authorities decide from case to case.

Water act: Not defined. It is at the discretion of the authorities.

MinroG: There is no fixed procedure. The authority decides from case to case.

41. What kind of permits or working plans is needed, if testing is needed?

A working plan, application at the Mining authority.

42. How is the permitting procedure to drill a side-track or to expand the depth of an existing well? What are the legal requirements?

The approval is the same. However, for a side-track there may be more participants in the process. This depends on the properties touched (even when touched at depth!) and the number of respective owners.

43. Are there specific environmental regulations in place for well reuse, and if so, what are they? Is there an obligation for an environmental impact analysis?

Same regulations as for deep drillings in general (minrog, WRG). There is no obligation for an environmental impact analysis for deep drillings in generall. This depends mainly on the location of the well and is only mandatory in certain protected areas (see also point 34).

44. Do you know any reasons why a reuse or the recompletion is forbidden? (e.g. region was repurposed as environmental protection zone…)

Less for legal reasons than for technical reasons. Environmental protection zones may not forbid a reuse, but maybe require special permits or an EIA.

45. Which entities are involved in the licensing procedure?

• Approval related to the Water act: water authority at local (districts) or regional (federal state) level • Mining law: national level (mining authority)

46. Who is the authority to supervise the repurposing process of abandonment wells?

• Mining Authority (Ministry of Finance: Bundesministerium für Finanzen; Sektion Bergbau; "Montanbehörde"; https://www.bmf.gv.at/themen/bergbau.html) • Water authority

47. Is there a One-stop shop system for application (one responsible authority for the execution of a licencing procedure)?

No, unless there is an EIA

48. Is an online application possible?

No

49. How long does a permission procedure take? Are there maximum time limits for procedures? Is there automatic permission after a deadline passed?

Water act 1959: For deep geothermal installations, concerning the water act there is no time limit for procedures when the licensing procedure is the regular approval process. For simplified procedures in the notification procedure, automatic permission applies after 3 months. Minrog: Experience shows that the approval process for deep geothermal systems often takes several years. If several procedures are necessary, they cannot always be carried out separately. However, since the submission may take place separately, this can lead to delays due to increased communication. Experience from the oil and gas industry: Approx. 6 months from submission to start. "One-stop shop" applies here, as everything is regulated by the mining authority.

50. How long is a permit valid?

As long as it is stated in the official notice. Maximum duration according to water act must be < 90 years. From practice 40 years known for hydrogeothermal plants (25 years for BHE).

Minrog: Depends on production or use. No experience with extensions as geothermal energy projects in AT have not been running for that long

Production licence for hydrocarbons
MinroG § 78 The commencement, any interruption lasting longer than six months and the resumption of the extraction of federally owned mineral resources or the storage of liquid or gaseous hydrocarbons in an extraction field shall be notified to the authority without delay. If extraction or storage is interrupted, the expected duration of the interruption must also be stated.

51. Is the permission related to special obligations during the installation and operation (e.g. reporting of production data)?

Obligations are stated in the official notice from the licencing procedure and depends on the installation.

Part 2 – Financial framework

The purpose of this questionnaire is to provide an overview of the financial framework for geothermal applications for reuse of existing wells.

Please note that reuse may require additional infrastructure compared to a conventional geothermal project because reuse is tied to existing sites. This means that heat exchangers or pipelines will be required to mitigate the reduced heat output.

Financial framework and funding

National funding

52. Is there national funding for geothermal applications based on reuse of existing wells? List the funding available.

YES, the KPCs (Kommunalkredit Public Consulting, a subsidy from the Ministry of Climate, Environment, Energy, Mobility and Innovation) funding scheme “Local heating supply based on renewable energy sources” includes the funding of reuse of existing wells. The description is included in the text box below.

If yes, please name it, give a reference, purpose, and amount. Who is eligible for a given programme or funding source?

The description is included in the text box below.

If not, are there suitable alternative funding schemes, which can be used for this purpose?

Next to KPCs funding scheme “Local heating supply based on renewable energy sources”, there are two more options that can fit for the reuse of existing wells. The description is included in the text box below.

53. Which are the typical timeframes for funding? Which types of the project they are covering (e.g. feasibility process, installation, operational phase). What are the requirements for funding?

The description is included in the text box below.

There are three funding schemes for (deep) geothermal energy installations, which are or might be suitable for the funding of reuse of existing wells too. Existing funding for deep geothermal energy projects is currently available from environmental funding (BMK – Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology, managed by Kommunalkredit Public Consulting). While examining the application, the KPC also checks which other EU funding (just EU funding, no funding from the federal states) can be used to finance the submitted project. Required information will be communicated.

For the full range of funding opportunities through the KPC see https://www.umweltfoerderung.at/.

The three environmental funding channels relevant to deep geothermal energy are presented below.

1. **Local heating supply based on renewable energy sources**

The eligible costs consist of costs for the system as well as for planning and assembly.

Eligible investment shares:

- **Deep drilling to supply individual customers or heating networks**
- **Re-compression**
- **Geothermal power heat coupling** Point of geothermal combined heat and power: with CHP, the funding is analogous to biomass CHP, the funding here is lower than that for local heat supply. The extent to which a geothermal system that additionally generates electricity falls under this point has been vaguely answered. However, it can be assumed that an ORC or Kalina system currently covers its own electricity needs and the system is therefore not considered a classic CHP system with feed into the grid.
- **geothermal reuse of existing boreholes**

Systems for raising temperatures are not eligible in this scheme: Point systems for raising temperatures: there is separate funding for the use of heat pumps (assumption of innovative local heating networks, note. Heat use at the Simmering sewage treatment plant was funded in this way). Deep geothermal systems that do not run without a heat pump are excluded from funding from the outset; additional heat pumps must be specifically applied for funding.

Funding conditions:

Technical requirements	Proof of the technical usability of the geothermal potential Re-injection of the thermal water Acceptance testing of the entire system
Funding basis	Eligible costs less the costs for a fossil heat generator with the same performance in accordance with established standard values
Funding rate	30% of the funding basis
Maximum funding	2.500 Euro/ton saved CO2 Max: 6 Million Euros

Minimum investment	35.000 Euros
Minimum CO2 savings per year	4 tons
Surcharge options	5% (max. 10.000 Euros) for EMAS certified companies

2. Heat pumps

Heat pumps with a nominal heat output of 100 kW or more and predominantly used for operational purposes are eligible for funding. Up to 20% of the eligible additional investment costs are supported.

3. Biomass – combined heat and power and wood gas production

If electricity is to be generated economically with a deep geothermal system (geothermal combined heat and power), the system is subject to the same funding conditions as for biomass - combined heat and power and wood gas production.

Funding basis	Eligible costs less the costs for a fossil heat generator with the same performance in accordance with established standard values
Funding rate	25% of the funding basis
Maximum funding	1.125 Euro/ton saved CO2 Max: 4,5 Million Euros
Surcharge options	5% (max. 10.000 Euros) for EMAS certified companies

Traditional and innovative financing options

54. Are there examples of financing options in your country listed in the Figure below? If so, please name and describe them.

While some of the financing instruments are available in Austria, none of hem relates directly to deep geothermal projects, or the reuse of depleted hydrocarbon wells. Therefore, these projects compete against projects with higher technology input or otherwise more appeal to the public.

Financing Instruments for Building Efficiency

SAPHEA
INTEGRATING GEOTHERMAL HEATING AND COOLING NETWORKS IN EUROPE

	Traditional	Innovative	
Non Repayable	Prizes, Subsidies and Grants Tax incentives	Energy Efficiency Feed-in Tariff	
Debt	Loans / Mortgages Credit Enhancers: Guarantees, Securities, Insurances, Additional Collateral, etc.	Green Loans / Soft Loans Green Bonds, Community/ Municipal Investment Bonds, Social Bonds Energy Performance Contracting (EPC) / Agreements (EPA)	Energy Service Agreement (ESA) Green Leasing, PACE Energy Efficient Mortgages On-Bill Financing Loans / Tariff Green Revolving Funds Crowdfunding
Equity	3rd Party Funding (Business Angels)	Energy Communities, Energy Cooperatives	
Other	Advisory Services Technical & Project Dev. Assistance Capacity Building	Energy Efficiency Quota Obligations One-Stop Shops	

55. Are there any other financing options in your country or do you know about any other in general (e.g. can be an example from another country)?

No

Other incentives

56. Are there any financial incentives for companies to locate in regions where abandoned wells are situated? If yes, please give a short description.

There are no financial incentives available that relate directly to areas with abandoned wells. However, some regions offer incentives in general because they are economically disadvantaged.

There is little overlap with areas of abandoned wells as typically the production of hydrocarbons improved the economics of these areas. Any financial incentive must be investigated on a case to case basis.

57. Does development or strategic planning for regions with abandoned wells exist?

No, there is no planning where the reuse of wells in incorporated.

Appendix 6 - Results Table

Questionnaire section		Question	HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA	EUROPEAN UNION	Question Nr.
A	Country update on well reuse	Reuse projects executed/on-going/planned	▪ state-owned wells 11 projects (thermal, balneological, electricity) ▪ company projects are on-going	▪ 3 HE fields executed ▪ 5 projects in planning phase/testing phase (HE)	▪ 3 projects executed (2 HE, 1 DBHE)	▪ 5 projects executed (2 EGS, 2 DBHE, 1 HE) ▪ 5 planning phase	▪ 3 projects executed (2 DBHE, 1 HE injector) ▪ ATES evaluation study	▪ not applicable as detailed on member country level	1
A	Country update on well reuse	Reuse attitude country wide	▪ state-owned wells ▪ public tenders ▪ own organisation: Mining Property Utilization Nonprofit Public Ltd	▪ only HE ▪ others no awareness	▪ some plans due to legislation changes	▪ some plans	▪ no awareness	▪ no focus	2
A	Country update on well reuse	Reuse - "political topic"	▪ yes	▪ only on local level	▪ no	▪ yes	▪ no	▪ no	4
A	Country update on well reuse	Definition of deep geothermal	▪ no regulation ▪ deep geothermal when > 60°C	▪ no regulation	▪ > 300 m (different laws applicable)	▪ > 400 m is considered as deep well (Mining Authority is involved)	▪ No definition of depth available ▪ Mining Authority involved > 300 m	▪ no regulation	5
B	Data, well ownership and well condition	Industries which use/need boreholes	▪ Oil and gas industry ▪ Agriculture ▪ Medical - Balneological ▪ Geothermal energy ▪ Food - Drinking Water, Botteling ▪ Mining ▪ Geological Research (Research Drilling)	▪ Oil and gas industry ▪ Agriculture (HE) ▪ Food - Drinking Water, Botteling ▪ Medical - Balneological ▪ Geothermal energy ▪ Geological Research (Research Drilling)	▪ Oil and gas industry ▪ Agriculture ▪ Medical - Balneological ▪ Geothermal energy ▪ Food - Drinking Water, Botteling ▪ Geological Research (Research Drilling)	▪ Hydrocarbon, underground storage (Gas) ▪ Mineral exploration ▪ Geothermal energy ▪ Geological Research (Research Drilling) ▪ Medical - Balneological ▪ Food - Drinking Water, Botteling	▪ Oil and gas industry ▪ Agriculture ▪ Medical - Balneological ▪ Geothermal energy ▪ Food - Drinking Water, Botteling ▪ Infrastructure ▪ Geological Research (Research Drilling)	▪ not applicable on this level	6
B	Data, well ownership and well condition	Legals/ differences	▪ A uniform system of rules for all industries and any kind of applications based on: ▪ Mining Law - XLVIII of 1993	▪ Act on the Exploration and Production of Hydrocarbons (*NN 52/18, 52/19, 30/21)*	▪ MINING ACT - Zakon o rudarstvu (ZRud-1), Uradni list RS, št. 14/14 – uradno prečiščeno besedilo, 61/17 – GZ, 54/22 in 78/23 – ZUNPEOVE ▪ WATER ACT - Zakon o vodah (ZV-1), Uradni list RS, št. 67/02, 2/04 – ZZdrI-A, 41/04 – ZVO-1, 57/08, 57/12, 100/13, 40/14, 56/15, 65/20, 35/23 – odl. US in 78/23 – ZUNPEOVE	▪ Mining Act ▪ Water Act ▪ Nature conservation	▪ Drilling a well > 300 m: same regulations for hydrocarbons, water or heat. ▪ Mining Act: MinroG (Mineralrohstoffgesetz) ▪ Water Act: WRG 1959 (Wasserrechtsgesetz)	▪ no legal regulation	8

Questionnaire section		Question	HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA	EUROPEAN UNION	Quest Nr.
B	Data, well ownership and well condition	Public data/attitude	▪ GeoBank database ▪ Core sample collection	▪ Partially: Datarooms (data under concession, investors pay; academia free) ▪ All data not under licence: free	▪ Database ▪ Data can be requested	▪ Stammdaten/Nachweisdaten (Master data) publicly available	▪ Public well data only available from (scientific) publications ▪ Webmaps (only coordinates) ▪ Data cannot be requested from Mining Authority or GeoSphere	▪ No data collected or maintained	9
B	Data, well ownership and well condition	Well status documentation	Data/status of well must be reported ▪ SARA (Supervisory Authority of Regulatory Affairs) ▪ Directorate of Geology into the GeoBank	▪ All data reported to Ministry of Economy and Sustainable Development ▪ Croatian Hydrocarbon Agency	For wells in production a report is mandatory; change of status must be reported to: ▪ Ministry of natural resources and space ▪ ARSO – Environmental Agency of Slovenia ▪ Directorate for Waters ▪ Mining Department	▪ Status must be reported to Mining Authority	▪ Status must be reported to Mining Authority	▪ No documentation requirements	11
B	Data, well ownership and well condition	Well status documentation access	Information is publicly available at ▪ SARA (Supervisory Authority of Regulatory Affairs) Directorate of Geology from GeoBank ▪ Mining Property Utilization Nonprofit Public Ltd.	Well database accessible at: ▪ Croatian Hydrocarbon Agency - records about status not complete (for reserach free, for commercial pay)	Data can be accessed for a certain fee or upon request: ▪ company Petrol Geo ▪ partly government owned	▪ Data at mining authority ▪ State offices have access to view data	▪ No public information about well status or planned abandon-ments ▪ Annual report publication about total number of producing wells	▪ No documentation requirements	10
B	Data, well ownership and well condition	Well owner	▪ permit holder ▪ state owned (600)	▪ investor/company/ permit holder/ operator ▪ after that State of Croatia	▪ operator/investor ▪ state	▪ permit holder/ operator/investor ▪ state	▪ permit holder/ ▪ operator/investor	▪ No information collected or maintained	12
B	Data, well ownership and well condition	Well abandonment timeframe	▪ immediate - 30-50 yrs ▪ normal 20 yrs	▪ > 180 d nothing > abandonment except force majeure	▪ theoretically after production stop, in reality much more time	▪ Normal case: 1-2 years	▪ depending on working plan (1-2yrs estimated)	▪ No regulation	17
B	Data, well ownership and well condition	Reuse obligation of drilled wells if dry	▪ no	▪ no	▪ no	▪ no	▪ no	▪ no	18

Questionnaire section		Question	HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA	EUROPEAN UNION	Question Nr.
C	Data, possible uses and utilisation	Documentation	▪ Well results - Implementation documentation	▪ Reports from exploration and research results ▪ Reports from well results ▪ Reports go to the Croatian Hydrocarbon Agency	▪ Production/Concession (Mining act): All collected data after concession finished and abandonment of the concession area is done. ▪ Production/Concession (Water Act): Drilling results have be provided to Directorate for Underground Waters	▪ Drilling plans need to be reported beforehand. ▪ Drilling report ▪ Reports go to Mining Authority and the Geological Survey	▪ Reports of well results (Bohrlochverordnung) ▪ Reports go to Mining Authority	▪ No information collected or maintained	20
C	Data, possible uses and utilisation	Data types freely available	▪ Basic well data are free ▪ Detailed data can be purchased through a one-stop system.	▪ Well data are partly free ▪ For academic and research use all data are free	▪ Basic well data are free: name, location, depth	▪ Basic well data are free ▪ Other data dependent on type of data and age	▪ No data are free - restricted ▪ Webmap services of Mining Authority show hydrocarbon licence boundaries	▪ No information collected or maintained	21
C	Data, possible uses and utilisation	Data owner	▪ State, company: ▪ The mining contractor and state-owned SARA (Supervisory Authority of Regulatory Affairs) Directorate of Geology	▪ State	▪ Company ▪ Geological Survey ▪ State after concession expires	▪ Dependent on type of data/type of drillings: company, survey ▪ e.g. state drillings (research) are free	▪ Company ▪ Mining authority after licence abandonment	▪ No information collected or maintained	22
C	Data, possible uses and utilisation	Data storage	▪ Well database at state-owned Supervisory Authority of Regulatory Affairs (SARA) ▪ Database at Directorate of Geology in GeoBank	▪ Hydrocarbon Agency ▪ Geological Survey (backup)	▪ Company internal databases ▪ Geological Survey ▪ Mining Authority ▪ University ▪ Municipalities	▪ Company internal databases ▪ Federal States Databases: splitted or combined databases between Geological Survey and Mining Authority	▪ Company internal databases (OMV AG, RAG Austria, ADX Energy) ▪ GeoSphere Austria ▪ Mining Authority (only applications, reports, administrative decisions)	▪ no regulations; currently no centralised data storage and, according to our research, there are currently no relevant initiatives.	25
C	Data, possible uses and utilisation	Well overtake	▪ In case of the state-owned wells the change of the ownership of a well is regulated by the State Property Act.	▪ Possible ▪ Transfer of rights and obligations can be partial or wholesome.	▪ Possible ▪ With a simple contract	▪ Possible ▪ Transfer of ownership with a contract	▪ Not applicable for single well (so far) ▪ Owner changes possible with employees and licence overtake	▪ No regulation	29
D	Legal framework, licensing/administration	Resource heat = raw material	▪ Yes, mentioned and described by the mining act as geothermal energy	▪ Not a raw material, but geothermal water is defined as water from which accumulated heat can be used	▪ Geothermal heat is defined as raw material in case the Mining law is applicable and a 100% reinjection rate is established.	▪ Yes and it is categorised as "Bergfreier Rohstoff" which means it is a resource free for mining	▪ No, geothermal heat is not considered a raw material or mentioned in any other ways	▪ No definition	33

Questionnaire section		Question	HUNGARY	CROATIA	SLOVENIA	GERMANY	AUSTRIA	EUROPEAN UNION	Question Nr.
D	Legal framework, licensing/ administration	Resource ownership	▪ State property in its natural place of occurrence and below 150 m depth ▪ regulated by the Mining Act	▪ State property in its natural place of occurrence and below 150 m depth, regulated by the Mining Act	▪ State property ▪ regulated by the Mining Act	▪ State property ▪ regulated by the Mining Act	▪ No ownership as heat is not considered as a resource ▪ Ownership and use are indirectly regulated by the Water Act	▪ No regulation	34
D	Legal framework, licensing/ administration	Entities involved in the licensing procedure	▪ SARA Mining Supervision Authority	▪ Ministry of Economy and Sustainable Development ▪ Croatian Hydrocarbon Agency	Ministry of natural resources and space ▪ ARSO – Environmental Agency of Slovenia, www.arso.gov.si ▪ Directorate for waters, Direktorat za vode | GOV.SI ▪ Mining department, Sektor za rudarstvo | GOV.SI	▪ Mining Authority ▪ Water Authority (regional) ▪ State Agency for Environment (Landesamt für Umwelt) ▪ District (Landkreis – several authorities: monuments, archaeology, forestry, regional planning, military, etc) ▪ BASE – Endlager ▪ Nature Conservation Associations (voluntary but strategically necessary)	▪ Approval related to the Water Act: Water Authority at local (districts) or regional (federal state) level ▪ Mining Act: national level (Mining Authority)	▪ No regulation	46
D	Legal framework, licensing/ administration	One-stop shop	▪ yes	▪ no	▪ no	▪ no/yes	▪ no	▪ not applicable	48
D	Legal framework, licensing/ administration	Online application	▪ yes	▪ no	▪ yes	▪ no	▪ no	▪ not applicable	49
E	Financial framework and funding	National funding for reuse	▪ no	▪ no	▪ no	▪ no (for HE only)	▪ yes	▪ no (apart from usual EU funding)	53
E	Financial framework and funding	Other/alter-native funding for reuse	▪ no	▪ yes (Norwegian Fund)	▪ yes (Norwegian Fund)	▪ yes	▪ no	▪ no (apart from usual EU funding)	55
E	Financial framework and funding	Incentives for reuse	▪ yes	▪ no	▪ no	▪ no	▪ no	▪ no	57
E	Financial framework and funding	Development plans for reuse	▪ no	▪ no	▪ no	▪ no	▪ no	▪ no	58