CROWDTHERMAL DELIVERABLE D3.1

CLUSTER ANALYSIS REPORT: UNADDRESSED ISSUES IN EXPLORATION RISK MITIGATION

Summary:

This Deliverable summarises the activities and findings of CROWDTHERMAL's Task 3.1 "Exploration risk mitigation clusters and dialogues". It presents the key synergies identified during the networking dialogues and the results from the demand analysis amongst various geothermal stakeholders. It concludes with recommendations on which issues shall be further considered for the risk mitigation component to be drafted within CROWDTHERMAL.

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Despite its huge potential to supply sustainable, decentralised and low-carbon baseload energy for electricity, heating and cooling, deep geothermal still plays a marginal role in the European energy mix.

The exploration risk as the risk of not finding a geothermal reservoir in sufficient quality or quantity for economically viable exploitation significantly contributes to the investment reluctance and the relatively slow development of the deep geothermal industry.

Several exploration risk mitigation facilities and insurance schemes with different regional focus and various concepts for risk-sharing have emerged or are currently being developed. What is missing however, is a pan-European exploration risk mitigation scheme open to all EU countries.

One of the main objectives of CROWDTHERMAL's WP3 is the development of recommendations for a novel exploration risk mitigation scheme that can complement alternative financing solutions throughout Europe. In this Deliverable, we derive first recommendation for the framework of this CROWDTHERMAL Risk Mitigation Component (RMC).

Our recommendations are based on more than 30 cluster dialogues and a demand analysis of unaddressed issues in geothermal risk mitigation amongst various stakeholders that were performed within the scope of CROWDTHERMAL's Task 3.1 "Exploration risk mitigation clusters and dialogues".

Cluster dialogues were established with international past and ongoing exploration risk mitigation schemes, geothermal project developers, investors, co-operatives, the insurance market, geothermal and institutional experts, research projects, geothermal energy policy initiatives and public authorities.

Possible key synergies between previous risk mitigation programmes and the new approaches being brought forward by CROWDTHERMAL were worked out. In particular, the CROWDTHERMAL RMC will build on the results of the GEOELEC/EGRIF and GEORISK projects, of which we give summaries in this Deliverable.

The demand for geothermal risk mitigation was determined via dedicated interviews with geothermal risk mitigation experts and project developers, and with the help of a risk demand questionnaire filled in by the promoters of the three CROWDTHERMAL Case Studies.

On the basis of the demand analysis, we conclude to focus the CROWDTHERMAL RMC on the exploration risk of deep hydrothermal projects for a minimum of two wells per project. The mechanism shall address both the short-term and the long-term resource risk in order to facilitate sustainable developments. It shall also consider drilling risks and drilling-related cost overruns.

The cluster analysis also confirmed that a new risk-sharing mechanism to complement alternative financing solutions should support different project sizes and allow for site-specific characteristics in risk profiles. The CROWDTHERMAL RMC will therefore be a mechanism independent of the particular Geothermal Play Type as classified by Moeck and Beardsmore (2014). A Play Type-independent exploration risk mitigation scheme can act as an important market incentive and contribute to an accelerated geothermal project development.

On the basis of our results and given the market conditions currently present in most of Europe, we stress the importance of a high involvement of national governments or transnational financing bodies in the funding of a geothermal risk mitigation scheme. We further highlight the importance of regulatory prerequisites, such as a geothermal law and public access to subsurface data for geothermal market uptake.

2 INTRODUCTION

2.1 GENERAL CONTEXT

Despite its huge potential to supply sustainable, decentralised and low-carbon baseload energy for electricity, heating and cooling, deep geothermal still plays a marginal role in the European energy mix. Like for any other energy technology, harnessing geothermal involves a variety of challenges, impacts and risks. This CROWDTHERMAL Deliverable 3.1 "Cluster analysis report: unaddressed issues in exploration risk mitigation" focuses on the exploration risk of deep, hydrothermal projects which – as a financial risk for project developers – is one of the main hurdles to geothermal energy development internationally.

The exploration risk (also geological, resource or discovery risk) is the risk of not finding the economically viable amount of energy, defined by temperature and productivity of a geothermal reservoir. Sometimes, also the risk of a technically challenging chemistry of the geothermal brine is subsumed under the exploration risk. The high exploration risk that is typically present in the early stages of geothermal project development (see Figure 1), makes it difficult to mobilise the required risk capital for funding early exploration surveys and first drillings. In order to realise investment in geothermal, it is necessary to provide sufficient investment security by mitigating the exploration risk (e.g. Wendel et al. 2010, Robertson-Tait et al. 2015).

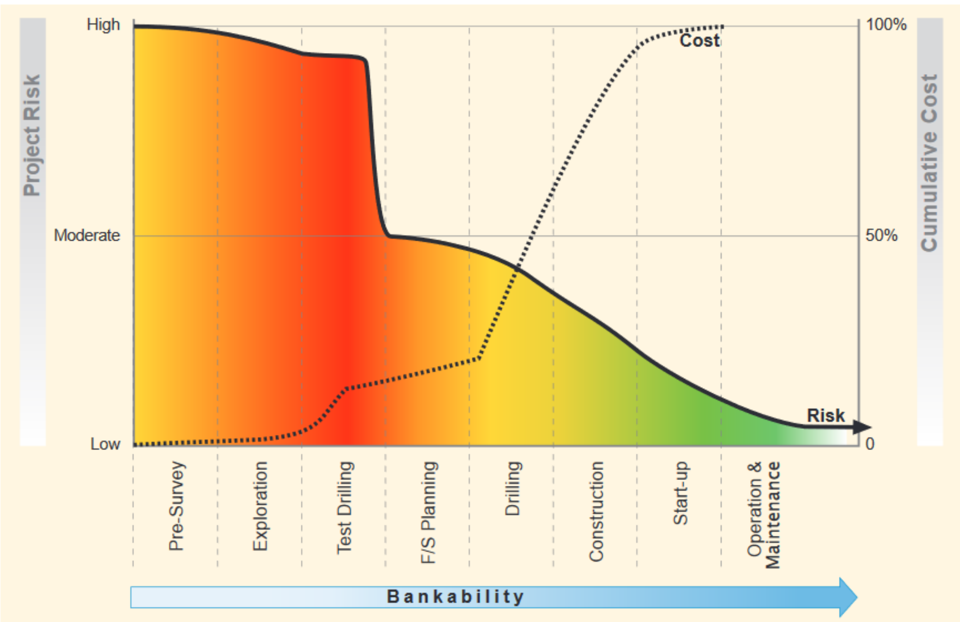

Figure 1: Typical risk and cost profile of a geothermal project (ESMAP 2012).

In order to overcome the difficulty of project developers in mobilising risk capital in the early project phases, several mechanisms have been developed for cost-sharing of the geothermal resource risk between the public and private sector. Countries like Germany, Switzerland, the Netherlands and France have established national governmental support or guarantee schemes mitigating the geothermal exploration risk (e.g. Fraser et al. 2013, Bonfait et al. 2018, Boissavy 2019). These schemes were very successful in stimulating the national geothermal market.

Beyond the national schemes, a number of larger, transnational risk mitigation mechanisms were implemented in various regions worldwide. Some of them, as for example the Geothermal Risk Mitigation Facility for Eastern Africa (GRMF) or Geothermal Development Facility (GDF) for Latin America, are funded by national or international bodies like the KfW, the EU or the World Bank Group.

A key feature that distinguishes risk mitigation mechanisms is how the funds are disbursed:

- As grant directly supporting the project finance
- As concessional loan which does not have to be paid back if the energy produced from a well is less than planned or
- As pure risk coverage in form of an insurance which is only paid out if the energy produced from a well is less than planned

Another distinctive feature is the project phase(s), in which the resource risk mitigation support is given. Geothermal risk mitigation schemes can:

- support the exploration phase prior to first exploration drilling (e.g. the ARGeo (African Rift Geothermal) risk mitigation fund for East Africa) – whereby this support can also include partial funding of the up-front infrastructure costs of a project (e.g. roads, bridges, pipelines),
- mitigate the risk of not finding an adequate resource in the first exploration drilling phase ("the short-term risk", e.g. the GRMF drilling grants),
- mitigate the risk that a resource cannot be sustainably produced in the operation phase ("the long-term risk", e.g. the French SAF Environnement Long Term Fund[1]

In some countries or regions, project developers also have the possibility to apply to private industry insurance companies or brokers for exploration risk coverage (see Kreuter & Baisch 2018). However, private market-based insurances can only be established if a sufficient number of projects have already been implemented, thus providing a statistical basis for calculating the probability of success. Since geothermal projects are still rare in most European countries, premiums for private market-based policies are high and only few project developers have the opportunity to obtain private market-based insurance coverage for their exploration risk.

In general, grant-based schemes are seen as the most appropriate support mechanism for juvenile markets, whereas private market-based insurance schemes are suitable for mature markets. Seyidov (2020) proposes a classification of support mechanisms relative to market maturities, whereby the market maturity is quantified by the Commercial Readiness Index (CRI) level of a respective national geothermal market (Figure 2).

[1] Strictly speaking, the long-term risk does not fall under the actual exploration risk present in the early project development phases.

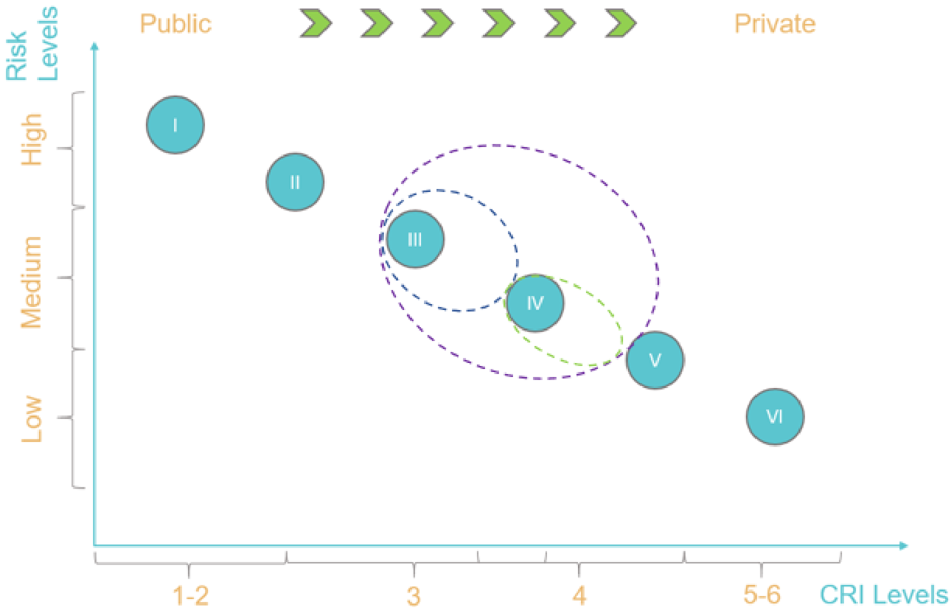

Figure 2: Risk mitigation schemes according to Commercial Readiness Index levels. I. Grants, II. Convertible grants, III. Repayable grants, IV. Public insurance scheme, V. Public-Private Partnership insurance, VI. Private market-based insurance. Blue circle: Contingency grants zone, Green circle: Loan guarantees zone, Purple circle: Private-Private Partnerships zone (©gec-co Global Engineering & Consulting - Company GmbH).

Currently, a variety of initiatives are underway to establish further geothermal exploration risk mitigation schemes internationally. As an example, the funding for the new geothermal risk guarantee fund GEODEEP that shall support deep geothermal projects in mainland France with repayable advances was given the green light in January 2020. In East Africa, the GeoFutures Facility is proposed as an improved and complementing scheme that shall draw upon best practices and lessons learned from previous programmes (Robertson-Tait et al. 2017). European projects like GEOELEC and GEORISK have worked or are still working on the establishment of pan-European and national risk mitigation schemes. We will monitor the evolution of these initiatives during the lifetime of CROWDTHERMAL.

Besides the exploration risk, there are a variety of other risks that geothermal project developers need to consider. These include environmental risks, such as potential induced seismicity, or groundwater contamination and the risk of low social acceptance. As CROWDTHERMAL's WP1 and WP2 specifically focus on environmental and acceptance risks, this Deliverable focuses on the exploration risk only. However, we will follow the evolution of WP1 and WP2 and their possible implications for WP3.

2.2 DELIVERABLE OBJECTIVES

This Deliverable "D3.1 - Cluster analysis report: unaddressed issues in exploration risk mitigation" summarises the activities and findings of CROWDTHERMAL's Task 3.1 "Exploration risk mitigation clusters and dialogues".

It lists the most important synergies that were identified during the desktop study, the networking activities and risk mitigation dialogues conducted by GeoThermal Engineering GmbH (GeoT) and consortium partners.

It also highlights the most important aspects of the demand analysis of geothermal risk mitigation, identifying issues currently not fully mitigated by existing schemes and recommended for further consideration in subsequent WP3 and WP4 Tasks.

In Task 3.2 "Alternative finance risk mitigation" (M1-14), GeoT will focus on specific risks being associated with alternative ways of geothermal project financing and social engagement as well as their possible mitigation measures.

In Task 3.3 "Design of auxiliary and alternative pathways to risk mitigation" (M1-M14), GeoT will give recommendations for a novel risk mitigation component (the CROWDTHERMAL RMC) that will be complementing the alternative financing solutions brought forward by CROWDTHERMAL.

The results of all WP3 Tasks will eventually feed into the CROWDTHERMAL core services in WP4.

In this Deliverable we give concluding recommendations on which results of the cluster dialogues and the demand analysis shall be further considered in our future WP3 and WP4 Tasks.

3 METHODOLOGY

Within the Task 3.1 Exploration Risk Mitigation Clusters and Dialogues, numerous networking activities were conducted. All partners were asked to get involved in the dialogues on geothermal risk mitigation.

Following up on a first brainstorming at the Kick-Off Meeting, a log spreadsheet documenting the work within the WP3 risk mitigation clusters and dialogues task was sent to all consortium partners, asking for contribution from the partners' networks.

In total, more than 30 cluster dialogues were established with geothermal project developers, investors, co-operatives, past and ongoing exploration risk mitigation schemes and initiatives, the insurance market, geothermal and institutional experts, research projects, geothermal energy policy initiatives and public authorities.

The three main discussion points were – all with the focus of geothermal risk mitigation in the context of alternative financing methods:

- Disseminate information about CROWDTHERMAL
- Identify possible key synergies
- Start the demand analysis / note unaddressed issues

All contributions to the log sheet from the consortium were compiled in a master spreadsheet by GeoT and distributed to the consortium partners for their reference. The log sheet can be found in Appendix 1.

The networking activities were supplemented by a desktop research by GeoT on past projects and initiatives with the focus of geothermal risk mitigation.

In addition to the first contacts of the cluster dialogues, more in-depth interviews were held by GeoT with risk mitigation experts from several organisations and programmes dealing with geothermal risk mitigation (namely the World Bank Group, GRMF, ARGeo, KfW and BGR-GEOTHERM-Programme). The dedicated interviews focussed on lessons learned from previous geothermal risk mitigation schemes and so far unaddressed issues in risk mitigation. The questionnaire used as a basis for these interviews can be found in Appendix 2. Interview protocols were prepared and finalised in co-operation with the interviewees. The most important findings from the interviews regarding the demand analysis for risk mitigation are summarised in Section 4.2.3 and were additionally recorded in the clusters and dialogues log sheet. The statements regarding alternative financing risks and risk mitigation will be analysed and presented in Task 3.2 / D3.2 (M12).

Furthermore, a questionnaire regarding risk assessment and risk mitigation demand analysis of the CROWDTHERMAL case studies was prepared by GeoT and sent to the case study partners. The questionnaire on the case studies' demand analysis for risk mitigation was filled in by partners SZDH (Szeged, Hungary), Geoplat (Madrid, Spain, 2 cases) and Eimur (Húsavík, Iceland). The filled in surveys can be found in Appendix 3. Finally, additional interviews were held with project developers who experienced project failure due to an unsuccessful well.

4 SUMMARY OF FINDINGS

In this Section, we summarise the results of the cluster dialogues, the desktop study and the demand analysis for geothermal exploration risk mitigation. We derive and clearly state the aspects we will further consider in our future tasks within WP3 and WP4. These passages are highlighted in orange.

4.1 MOST IMPORTANT SYNERGIES

This Section introduces the most important past and ongoing projects focussing on geothermal exploration risk mitigation as they were identified during the cluster dialogues and the desktop study. Our future work within WP3 will substantially build on the results of these initiatives.

4.1.1 GEOFAR / GeoRiMi

The project GEOFAR (Geothermal Finance and Awareness in European Regions; Wendel et al. 2010) was launched in September 2008 during the global financial crisis and under the Intelligent Energy Europe Programme (IEE II). One of its main objectives was to develop a geothermal risk mitigation scheme for Europe. Eight European target countries were included in GEOFAR (Germany, France, Greece, Spain, Portugal, Bulgaria, Slovakia and Hungary).

GeoRiMi (Geothermal Risk Mitigation) was the proposed financial scheme of GEOFAR. Project developers, banks and local public authorities could all participate as essential parts of the GeoRiMi programme. The financing of GeoRiMi was planned to be shared between the European Commission with 60%, the European Investment Bank (EIB) with 30% and the remaining 10 % to be open to financial institutions (Garcia 2010).

The concept of GeoRiMi was based on the following principles (Wendel 2010):

- support of investment in geothermal projects in the exploration and drilling phase,
- private investors must provide a significant part of the total investment,
- publicly-funded support has to be limited in time and total amount,
- publicly-funded support to be provided to cover exploration and drilling risk only,
- for all other purposes publicly-funded support has to use the normal business financing conduits, and
- regional and local public authorities must be supported in their efforts to understand and develop geothermal resources in their jurisdiction.

The proposed GeoRiMi scheme was meant to consist of three instruments addressing different project phases and beneficiaries:

- co-financing of pre-feasibility studies to be commissioned exclusively by regional and local authorities in areas with geothermal potential in which awareness of the potential is inadequate,
- extending partial guarantees to the exploration phase of qualified geothermal energy projects, and
- extending partial guarantees to the production drilling phase of qualified geothermal energy resources.

The proposed steps for the implementation of GeoRiMi were:

- a reality check with national and international financial institutions,
- a due diligence by financial institutions, and
- the preparation of an EU framework for embedding GeoRiMi.

The external experts of the target group and key actors involved in the reality check were representatives from e.g. EIB, KfW, Islandsbanki, Greek Ministry of Development, Bavarian Ministry of Economy, SOGEO, Pethraterm Espana, ADEME, and Slovak Innovation and Energy Agency (IEE 2020).

As a specific example, the proposed financial scheme for Spain was presented by Garcia (2010):
In the exploration phase of a project, the project developer would have to finance at least 40 % of the exploration costs. The rest was meant to be covered via credits from financial institutions. In case the project would have to be abandoned due to negative exploration results, the financial institutions would receive the money back from the local authorities. In case of positive exploration results, the investors would have to contribute 33 % of the drilling costs in the drilling phase of a project. The rest was meant to be covered via credits from financial institutions. In case the project would have to be abandoned due to negative drilling results, the financial institutions would receive the money back from the local

authorities. If case of successful drilling, no further financial contributions could be received from GeoRiMi.

GeoRiMi was planned to be implemented in 2011, but has never been put into practice. However, the efforts of GEOFAR were considered and continued by the GEOELEC project (see below).

We will consider the results of the GEOFAR project for the framework of the CROWDTHERMAL RMC.

4.1.2 GEOELEC / EGRIF

The EGRIF (European Geothermal Risk Insurance Fund) is the insurance scheme for financial geothermal risk mitigation that was developed within the GEOELEC project (Develop Geothermal Electricity in Europe, 2010-2013) under the Intelligent Energy Europe Programme (IEE) (www.geoelec.eu). The EGRIF is based on the experience of previous schemes like the French SAF Environnement and the Dutch Geothermal Guarantee Scheme and also builds on the work of GEOFAR. The EGRIF framework, including eligibility, evaluation criteria and the application process are specified in detail in Fraser et al. 2013.

The rationale of EGRIF is to start with a scheme supported by public money, and after having reached market maturity (i.e. when costs have reached grid parity with ca. 10 €ct/kWh), it should successively be replaced by private market-based schemes.

The beneficiaries of EGRIF could be private or public organisations wishing to develop high- or low-temperature electricity projects on the EU territory. As a specific feature, the EGRIF also includes EGS projects.

The EGRIF is meant to support the exploration phase, the short-term risk and the long-term risk. Based on the experience with other European geothermal risk mitigation schemes, the fees to be charged to the projects should be as follows (Fraser et al. 2013):

- The exploration phase: a 6 % to 8 % interest rate for a repayable advance
- The short-term guarantee: a premium amounting to 3.5 % to 5 % of the eligible costs
- The long-term guarantee: a fixed fee of 12.000 € to 13.000 € per year

These insurance fees might be modulated according to the estimated resource risk. They shall be set in the reference contract signed between the developer and the governance.

Important examples of the eligibility criteria for the applications are (Fraser et al. 2013):

- Technical: the expected parameters (flow rate and temperature); a reservoir development concept; the drilling path and well design; a stimulation concept; an estimate of the probability of success to achieve the expected flow and temperature; the planned utilisation of the thermal energy depending on the achieved parameters
- Financial/economical: available financing; a business plan; the expected return on investment
- Legal: all necessary permits and licenses; information on contractors and key personnel; the legal form and identity of the operating society

For the EGRIF, the insurance process:

- Could rely on independent expertise
- Could allow applications to be submitted continuously or on a tendering basis
- Should systematically lead to the conclusion of a reference contract between the developer and the Fund
- Should include some reporting obligations
- Should apply one or several languages, which should be clearly chosen
- Should be clear, transparent and lead to public and reasoned decisions

The seed capital (minimum 50-100 Mio. €) should have as many diversified sources as possible, e.g.:

- The European Union
- The Member States
- The regional level authorities of the Member States
- Insurance companies and brokers
- Private and public financial institutions
- Other reliable stakeholders.

The EGRIF shall rely on a strong capital and financial structure. Therefore, there should be a possibility of reinsurance as well as the likelihood of a balancing of the Fund. The governance of the EGRIF shall be allowed to make investments with the treasury and use the proceeds of these investments as an income. EGRIF shall also be able to exhaust and be replenished with available public and private funding.

Two options were discussed by Fraser et al. (2013) for the insurance of geothermal projects with all their advantages and disadvantages: (i) independent of the insurance instruments available in some European countries (Figure 3) and (ii) depending on existing insurances (Figure 4).

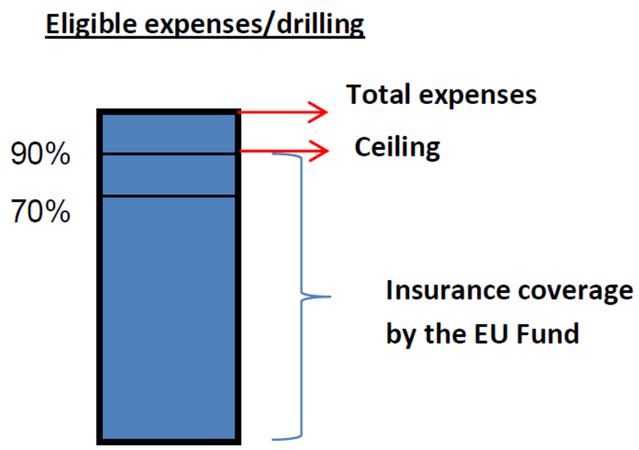

Figure 3: EGRIF scheme independent of existing insurances in the respective country (Fraser et al. 2013).

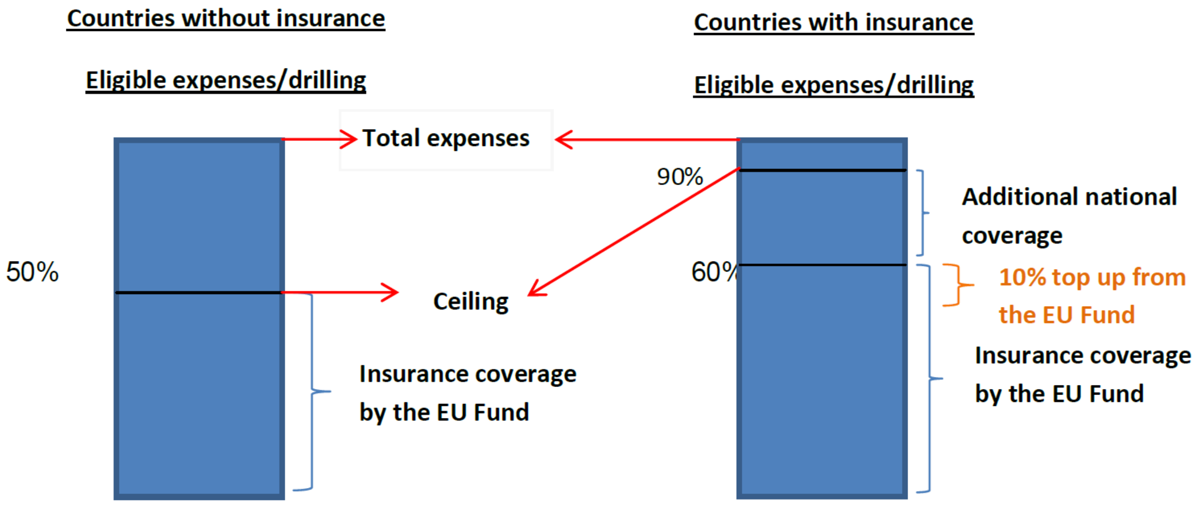

Figure 4: EGRIF scheme depending on existing insurances in the respective country (Fraser et al. 2013).

Up to now, the EGRIF has not been implemented. The GEORISK project (see below) however continues the work of GEOELEC/EGRIF and currently works on the establishment of several national risk mitigation schemes in Europe.

The results of GEOELEC will find their way into the CROWDTHERMAL project via the participation of P. Dumas (EGEC) and A. Manzella (CNR-IGG), both members of the GEOELEC consortium, in the Advisory Board of CROWDTHERMAL.

We will align the framework of the CROWDTHERMAL RMC to the one recommended by GEOELEC/EGRIF and will adapt their results to the context of CROWDTHERMAL.

4.1.3 DARLINGe

The Interreg Danube Transnational Programme DARLINGe (Danube Region Leading Geothermal Energy, duration 2017-2019) involved the six countries Hungary, Slovenia, Croatia, Serbia, Bosnia and Herzegovina as well as Romania (Figure 5).

The project's specific objectives were (Interreg Danube 2020):

- to increase the use of geothermal energy and help the penetration of energy efficient cascade systems and matching them with existing heat-market demands
- to establish a market-replicable tool-box consisting of three complementary modules for sustainable management of deep geothermal resources (an independent indicator-based benchmark evaluation of current uses, a decision tree to help developers, and a geological risk mitigation scheme to maximize the success rate of a first geothermal well), and to test these tools on three cross-border pilot areas
- to advance stakeholder cooperation to foster geothermal developments and to create a strong geothermal value chain.

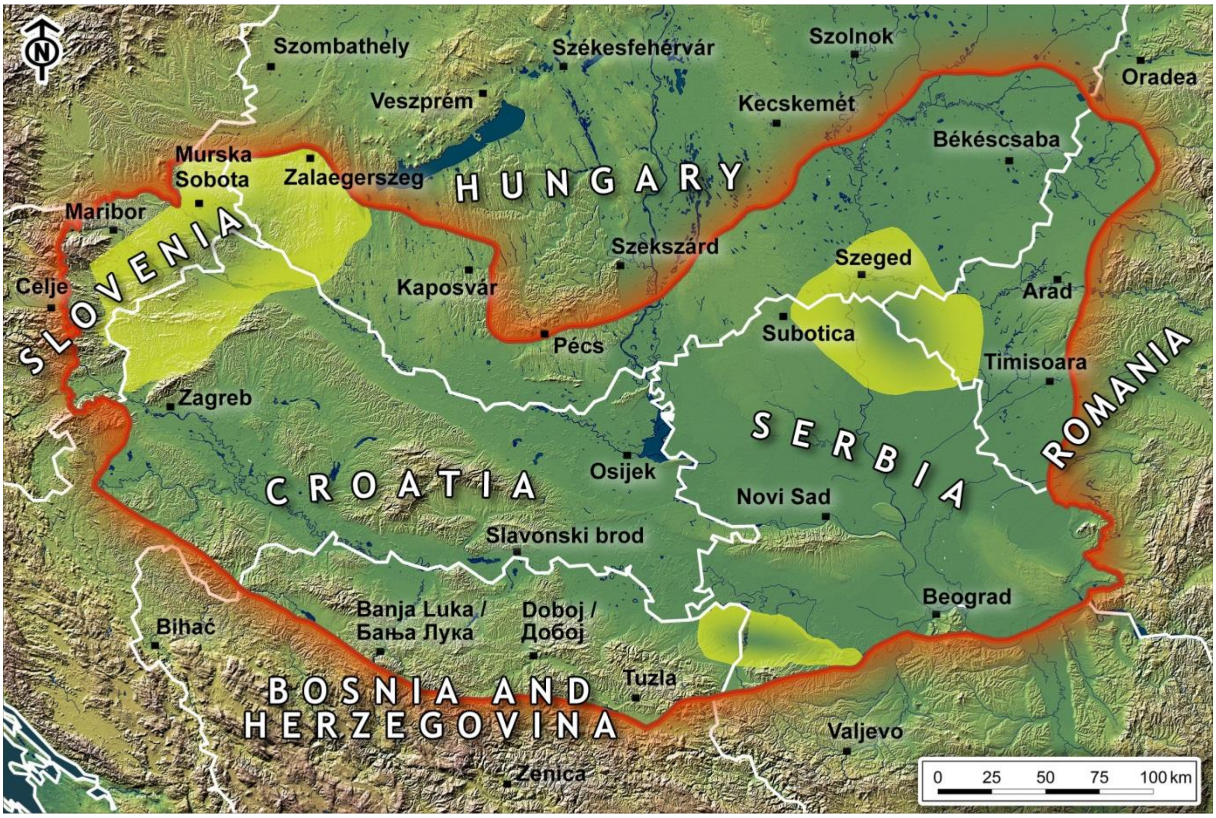

Figure 5: DARLINGe project area (red contour) with three cross-border pilot areas (light green). Source: Interreg Danube 2020

The most relevant synergy aspect to be discussed in the following is the DARLINGe toolbox of the geological risk mitigation scheme (Nádor et al. 2018):

The risk mitigation scheme of DARLINGe exclusively deals with resource-related risks of classical deep hydrogeothermal projects (doublets) in the southern part of the Pannonian Basin tapping fractured and porous aquifers.

The procedure of the scheme is shown in Figure 6. Only the problems which can occur during drilling, testing and operation were considered. Those defined problems are called "damages" since they might prevent, slow down and/or increase the costs of project development.

Examples of damages are: (i) a complete loss of the well (e.g. due to missing reservoir formation), (ii) a lower than expected flowrate, and (iii) increased operational costs. The related mitigation measures are: (i) enhanced geological interpretation concerning target faults and karstified tops of geological units, (ii) use clay mineral-free drilling mud, and (iii) monitor fluid chemistry and evaluate corrosion and scaling potential. Examples of respective amending activities are: (i) drill further until the targeted reservoir is reached, (ii) stimulate the well (thermal, chemical or hydraulic) and (iii) use inhibitors via coiled tubing.

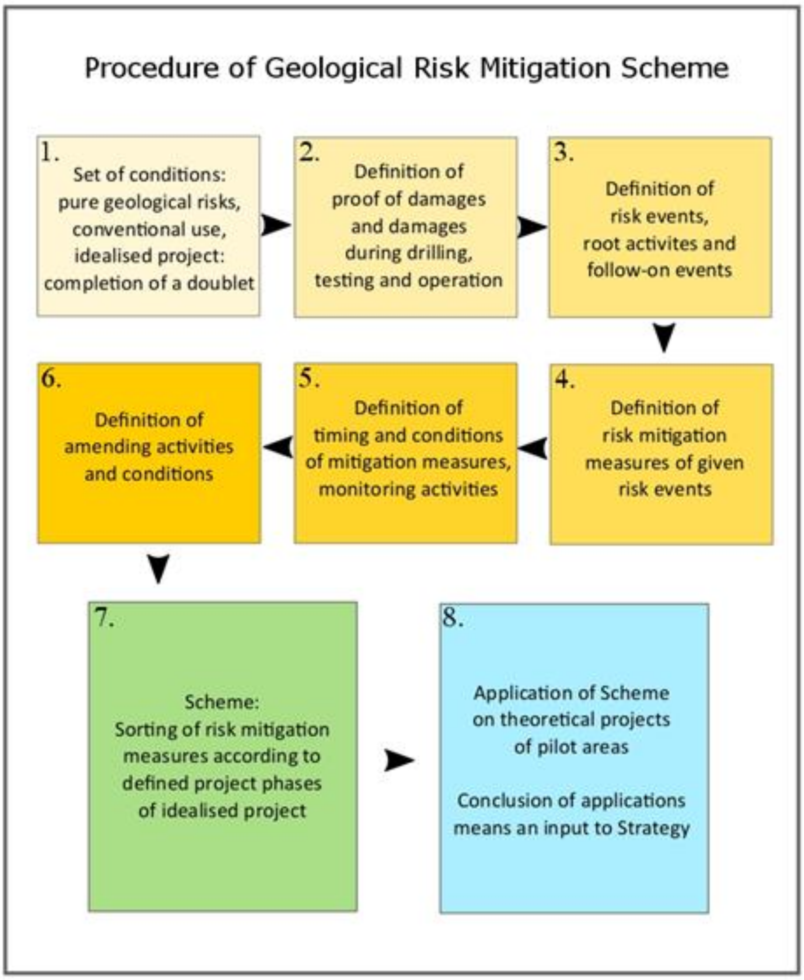

Figure 6: Procedure of the geological risk mitigation scheme in the DARLINGe project (Nádor et al. 2018).

The result of the scheme is a list of mitigation measures according to project phases which can be narrowed down based on the site-specific conditions and the available geological knowledge of the area (Ádám et al. 2019). The scheme thus provides a guideline and strategy for project developers to identify the kind of mitigation measure and to apply it in due time during the different project phases for avoiding different possibly occurring damages to geothermal projects being implemented in the geological environment of the southern Pannonian basin.

The work of DARLINGe with respect to geothermal risks and risk mitigation has been considered and is continued by the GEORISK project (see below). The know-how transfer into CROWDTHERMAL is ensured through the participation of partner SZETÁV in both project consortiums.

Certain aspects of the DARLINGe tool-box could serve as a blueprint for a geothermal risk guide as part of the CROWDTHERMAL RMC.

4.1.4 GEORISK

The ongoing H2020 project, GEORISK (https://www.georisk-project.eu/) works on the establishment of financial schemes mitigating the exploration/geological risk through conventional financial instruments lowering the financial exposure of developers in case of failure to develop a geothermal reservoir. This is planned for all European countries and in some key target third countries. GEORISK thereby continues and considers the work that has been done in this field in previous projects like GEOFAR, GEOELEC (EGRIF) and DARLINGe.

The synergistic co-operation with GEORISK is facilitated through the subcontractor involvement of GeoT in the project as well as the participation of GEORISK co-ordinator P. Dumas (EGEC) in the CROWDTHERMAL Advisory Board.

As the basis for GEORISK's work, the first major task was the identification of all possible risks in geothermal project development as well as their classification and compilation in a Risk Register (Le Guénan et al. 2019). The register is based on the analysis of about 70 documents of previous projects and studies dealing with risks in geothermal. It identifies the roughly 50 main risks faced by project developers and operators. Each risk is characterized by a description, the corresponding project phases, types of consequences, and possible technical and financial (insurance) mitigation measures. The risks are organised into the categories "external hazard", "risks due to uncertainties in the external context", "risks due to internal deficiencies", "risks due to subsurface uncertainties", "technical issues" and "environmental risks" whereby the focus of GEORISK lies on "risks due to subsurface uncertainties".

An online version of the Risk Register is available as the so-called GEOriskREPORT at https://www.georisk-project.eu/register/. This online tool includes a list of the main risks to be faced by developers, the corresponding mitigation measure, the results of the GEORISK Risk Assessment (see below) and a downloadable risk assessment sheet. The GEOriskREPORT can thus serve as an interactive risk mitigation guide for project developers and can help to shape a project-specific risk management plan.

On the basis of the risk identification, GEORISK performed a risk assessment via a survey in which each risk of the Risk Register was rated and ranked by geothermal stakeholders (drilling companies, research institutions, geothermal project developers, insurance companies, consultants) with respect to the current market situation in the local context of the target countries (Seyidov 2019a).

The results allow for an understanding of the challenges that local markets are currently facing in the fields of socio-economy, geology and drilling. Figure 7 and Figure 8 depict the GEORISK Risk Assessment results aggregated over the countries Hungary (18 responses), Poland (10 responses), Greece (7 responses), Germany (4 responses), Switzerland (4 responses), France (4 responses) and Turkey (6 responses). They show the risk indexes (calculated from the expected damage level and likelihood of occurrence) and the relevance (subjective estimate of the level of challenge and possible project delays that a developer faces encountering a specific risk), respectively.

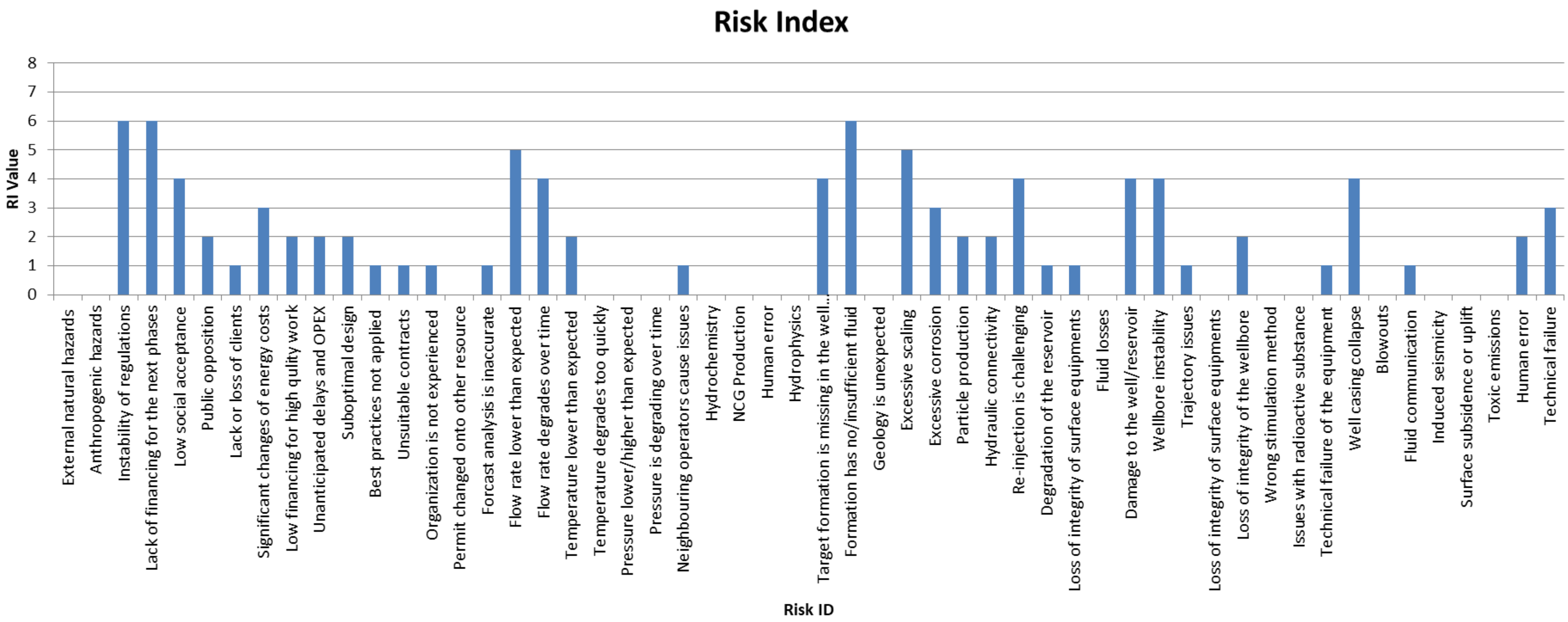

Figure 7: Risk indices of geothermal risks as compiled by the GEORISK Risk Assessment (Seyidov 2019b).

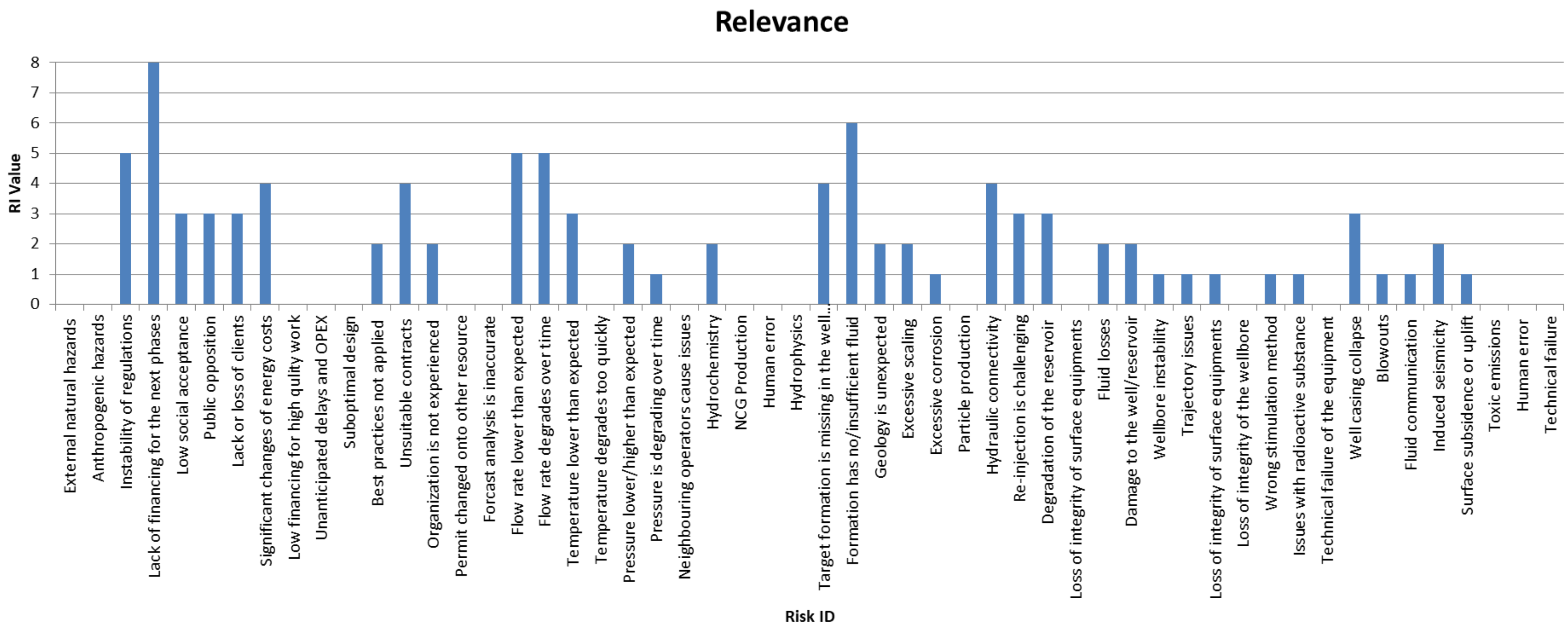

Figure 8: Relevance of geothermal risks as compiled by the GEORISK Risk Assessment (Seyidov 2019b).

Although the survey results show differences across the surveyed countries, the majority of the risks are geology-related. One of the frequently mentioned risks was the inability to secure the geothermal resources, either by inability to reach the target or the target formation characteristics deviating from the prognosis (e.g. target formation has no/insufficient fluid, flow rate lower than expected, flow rate degrades over time, target formation missing in the well). This stresses the importance of improved subsurface exploration and the accessibility of underground data to the geothermal industry.

In case of socio-economic risks almost all countries have given a high value to the lack of finances and political regulatory environment stability, thereby indicating the crucial importance of both financial support schemes and a supportive, stable regulatory environment for the development of the projects.

Surprisingly enough, very often the average level of drilling risks was lower than the one of other sections. The reason behind this could be lying in the fact that most of the difficulties have a geological background. Since these are being presented in the section for geology, the drilling risks represent purely technical procedure challenges. This however raises the important issue of potential inter-dependencies between risk categories. The other reason for the low level of drilling risks might lie in the vast experience gathered by the drilling companies in the oil and gas industry. Drilling risks could be minimised if the geological pre-setting is well known, personnel are experienced and enough financial resources ensure best practice standards (Seyidov 2019, pp. 66-67).

We will consider the highest and most relevant risks identified in the GEORISK Risk Assessment (namely the lack of financing for the next phases, insufficient fluid/flow rate, flow rate degrades over time) in the CROWDTHERMAL RMC.

Besides the Risk Assessment, GEORISK has also compiled an inventory of past, existing and planned risk mitigation schemes, focusing on the successful ones like the French SAF Environnement, the Dutch Geothermal Guarantee Scheme and the Turkish Risk Sharing Mechanism (Boissavy 2019).

On the basis of a review of 14 specific European risk mitigation schemes, GEORISK further identified five key aspects that need to be taken into account and addressed when establishing a new risk mitigation scheme, namely (Lupi & Siddiqi 2019):

1. Legal and regulatory boundary conditions (What is the basis for a specific risk transfer mechanism?)
2. Identification of the risk(s) to be addressed (Which precise risk(s) need(s) to be transferred?)
3. Funding of the risk transfer scheme (How is the risk transfer mechanism financed?)
4. Procedural aspects (What is the process for granting aid?)
5. Performance indicators (How is the risk mitigation scheme performing?)

Considering these key aspects, the establishment of national risk mitigation schemes is currently ongoing in Hungary, Poland and Greece. In a number of workshops with key national stakeholders, framework conditions like scheme sponsor, geographical, professional and geological scope, premium and risk coverage levels and operational details are being discussed and determined. Eventually, a replication in other target countries as well as international third countries is foreseen.

We will consider the key factors of successful risk mitigation schemes identified by GEORISK (e.g. type of scheme, projects to be covered, risks to be addressed, premium and coverage ratios) for the CROWDTHERMAL RMC.

Beyond the establishment of geothermal risk mitigation schemes in target countries, GEORISK also aims at facilitating the transition of existing insurance scheme in Europe (France, Germany, Turkey, Switzerland, Denmark, The Netherlands) according to the market maturity of the sector. For this, the project looks at local market maturities and the appropriate risk mitigation mechanism for a given market condition. A transition from public grant-based schemes to public and eventually private market-based insurance schemes is only appropriate for relatively mature markets (Seyidov 2020, see also Section 2.1).

Finally, GEORISK has launched an online helpdesk for public authorities summarising the most important questions and answers for decision-makers and investors considering setting up or sponsoring a de-risking scheme for geothermal. The helpdesk can be accessed via the GEORISK homepage at https://www.georisk-project.eu/helpdesk/.

We will follow the evolution of all GEORISK workpackages in order to consider the relevant results for the CROWDTHERMAL RMC.

4.2 DEMAND ANALYSIS GEOTHERMAL RISK MITIGATION:

In addition to a general lack of an international or pan-European geothermal risk mitigation scheme, also the established mechanisms do not always consider all hurdles of geothermal project development.

Examples are the long-term operational risk of geothermal projects (i.e. the risk of decreasing energy production due to e.g. scaling or thermal break-through), cost overruns while drilling (e.g. lost-in-hole requiring expensive side-tracks or the loss of the well) as well as the challenge of follow-up financing after successful drilling of the first well.

Task 3.1 therefore also included a demand analysis identifying the most important unaddressed issues as they are perceived by the following stakeholder groups:

- Geothermal project developers
- Developers who already experienced project failure and thus financial risk materialisation
- Geothermal risk mitigation experts
- Insurance companies

The following Sections highlight some of the issues that arose during the demand analysis for geothermal risk mitigation amongst these stakeholder groups. For the key aspects, we discuss their relevance in the context of CROWDTHERMAL and will conclude whether or not the respective aspect will be further considered in the CROWDTHERMAL RMC.

4.2.1 The Project Developers' Perspective

The perspective of geothermal project developers or investors is represented by the CROWDTHERMAL case studies in Szeged (HU), Madrid (ES) and Iceland (IS). The anticipated needs of the case studies were compiled via a Case Study questionnaire on the geothermal risk mitigation demand that was filled in by partners SZDH, GEOPLAT and EIMUR. The completed questionnaires can be found in Appendix 3.

The following Section summarises the most important findings regarding the Case Studies' predominant risks as well as an indication whether or not these risks will be further considered for the CROWDTHERMAL RMC.

Demand Analysis Risk Mitigation: Szeged (HU)

The Szeged Case Study consists of a large-scale district heating project by the District Heating Co. of Szeged (SZETÁV) and its consortium partners. In the course of the project, 27 deep thermal wells (9 production and 18 injection) are drilled to a depth of 1,700 - 2,000 m, envisaged to produce about 20 l/s thermal water at about 90 °C.

The upper Pannonian Sandstone reservoir under Szeged is fairly well known and highly probable to bear thermal water. A completely dry well is therefore unlikely. Still, cooler temperatures from production wells or higher pressure needed for injection are very much possible. As such, the exploration or resource risk is also present for the Szeged case study.

The CROWDTHERMAL RMC will focus on the exploration risk.

For the case study of Szeged and its large number of wells to be drilled, some sorts of technical drilling risks and/or drilling delays are expected. Unplanned incidents during drilling bear the risk to put the entire project in danger. However, since an insurance company had to pay more than 300.000 € to cover a drilling incident[2] associated with the geothermal district heating development in Makó near Szeged, there is currently no insurance policy available for drilling companies to mitigate drilling risks. At the moment, insurance is available for above surface operations only: drilling companies can buy insurance to cover their losses when they move their rigs and equipment from one site to another but once they start drilling, they are not covered.

Interestingly, the GEORISK Risk Assessment survey came to a slightly different result. The highest risks were generally seen in the geological category. In the majority of countries, drilling risks were not seen as overly challenging (Seyidov 2019a). This underlines the facts

[2] During the drilling of the first injection well, the rig got stuck, presumably due to a casing collapse caused by natural gas entering the borehole. Eventually the liquid cement used for the casing entered the hole and the well had to be abandoned.

that different reservoirs present different risks and that local conditions always need to be taken into account for successful project-specific risk mitigation.

While it will not be our primary focus, we will still consider drilling risks and drilling-related cost overruns in the CROWDTHERMAL RMC.

For the Szeged case study, scaling during operation will likely be a serious issue threatening to damage pumps and other expensive equipment. The operator plans to draft and implement a complex water treatment plan in order to mitigate this substantial risk.

Although its organisational implementation in a risk mitigation scheme from the beginning is expected to be difficult, we will further consider the scaling and other long-term operational risks (i.e. the risk of decreasing energy production e.g. due to declining flow rates or thermal break-through) in the CROWDTHERMAL RMC.

The risk of low public acceptance is also predominant in the Szeged case study. A well-coordinated and professional information campaign able to grasp and communicate the technical elements is needed.

Communication, public relations and strategies to engage the public are topics to be primarily considered by WP1 and WP2. Therefore, the CROWDTHERMAL RMC will not specifically consider the risk of low social acceptance.

Demand Analysis Risk Mitigation: Madrid (ES)

The Spanish Case Studies "Arroyo Bodonal Cooperative" and "EAI310 Cooperative" are two housing co-operatives that use shallow geothermal to provide heating, cooling and domestic hot water. The projects were entirely financed by about 80 / 220 members. As shallow geothermal energy projects with closed loop systems, there was no risk associated with the geothermal resource.

The largest perceived risk however is one that also applies to deep geothermal projects to be crowdfunded: the lack of trust and credibility vis-à-vis financial entities (reluctant to finance the project), city councils (reluctant to issue permits) and construction companies (trying to change the concept). In this context, it was very important to co-operate with an expert or consultant with deep knowledge on geothermal (here the architect), to obtain the LEED platinum certification as an objective proof of efficiency and sustainability in the Arroyo Bodonal case and to follow the Trias Energetica Concept as a sustainability model in the EAI310 case.

We will further consider tools that can increase confidence and credibility of a crowdfunded geothermal project towards all stakeholders within Task 3.2 "Alternative finance risk mitigation". Possible examples are official sustainability certifications/concepts/labels, institutional match funding, patronage of well-known personalities from the renewable energy community and the involvement of geothermal experts. On these aspects, we will co-operate with WP1 and WP2.

Demand Analysis Risk Mitigation: Húsavík (IS)

The status of the Icelandic case study is different than the others as it is not fully designed yet. Eimur as the consortium partner responsible for the Icelandic case study is currently working on finishing the case design. At this stage, it is planned to consist of a community greenhouse heated by geothermal in the town of Húsavík where geothermal has already been utilised for over a century.

As the geothermal resource is already being exploited and its characteristics and capacity are well known, the geological or exploration risk is not a central issue in the Icelandic case study.

The commercial relationship between resource owners and the project is still under development. In this preliminary design phase, the largest risk is seen in the funding – how to get the crowd to care and how to get people and businesses involved and willing to fund the project.

Crowdfunding in itself presents one possible pathway to financial (and acceptance) risk mitigation whereas public engagement in financing the project development can result in multiple benefits for the project developer. WP2 specifically deals with this means of financial risk mitigation, the challenge to ensure sustainable (financial) interest of the involved public and the outline of viable business models including public participation. They are therefore not a particular focus of WP3. Yet, we underline the requirement of the Icelandic case study to especially involve local farmers and producers who might see the planned greenhouse project as potential competition.

4.2.2 The Failed Projects' Perspective

In addition to future and currently successful geothermal project developers, also former developers and investors who experienced a project failure due to an unsuccessful well and thus financial risk materialisation were interviewed.

Interviews were held with the following geothermal project developers / investors:

- Dr. Horst Kreuter, former CEO of HotRock GmbH (currently CEO of GeoT) and Project Manager of the deep geothermal project Offenbach an der Queich, Germany
- Andreas Gahr, CEO of Projektgesellschaft Enex Geothermieprojekt Geretsried-Nord GmbH & Co KG and Project Manager of the deep geothermal project Geretsried, Germany

The deep geothermal well in Offenbach an der Queich in the German Upper Rhine Graben was drilled in 2004 with the result of hardly any fluid losses and low injectivity. Several side-tracks were attempted but failed due to drilling-related technical problems. As the project did not have any public or private exploration risk insurance, a financial loss of more than 10 Mio. € had to be recorded.

One lesson learnt from this project was that a 3D seismic survey is indispensable for deep geothermal exploration in the Upper Rhine Graben. Additionally, the drilling rig was only just large enough for the planned well target without capacity reserves for a side-track to distant alternative targets. A public funding scheme might have led to the decision for a larger drilling rig with more capacity reserves. Possible re-use options like a deep borehole heat exchanger were checked, but impossible due to the lacking local heat demand.

We stress the importance of industry standards in geothermal exploration as well as contingency planning.

As opposed to the Offenbach project, the exploration risk of the deep geothermal well in Geretsried in the Southern German Molasse Basin (drilled in 2013) was insured by a private market-based policy. The policy was structured and formulated according to best practice standards. Consequently, the claim was settled without dispute when the well proved to be dry. Still, the investor had to record a loss of more than 10 Mio. € due to capital-intensive, prior infrastructure investments like roads and drill-pad construction that were not included in the insured risk.

A further consequence of the insurance claim was the withdrawal of the contracted insurance company from the German geothermal market for the time being. The national geothermal market was and still is too small and risk-prone for a private market-based insurance company to justify their engagement on a commercial basis after a first substantial loss.

Further endeavours to obtain insurance coverage for future drilling works by a public insurance scheme formerly available on the German market failed due to the difficulty to find a so-called "Hausbank" (a bank being affiliated to the project developer) willing to act as a clearing bank for the application (for details on this issue see Kreuter & Baisch 2018).

The drilling of a side-track in this project was financed by an institutional fund, with the support of an R&D program and funding in 2017. Since the side-track proved to be dry, too, the Geretsried developers currently work on innovative and potentially disruptive options for the re-use of the unsuccessful well, one being an EGS stimulation approach in carbonates.

The Geretsried example shows that even in regions like the German Molasse Basin with a growing number of successful geothermal district heating projects, the market is not mature enough to sustain a private market-based exploration risk mitigation scheme. If further market uptake is desired, the involvement of national governments and public money in risk-sharing for geothermal projects is a key prerequisite.

It also demonstrates the fact that even with the existence of exploration risk coverage, geothermal developments involve a large and often incalculable financial risk. This needs to be taken into account when envisaging community-based financing for early development phases of a geothermal project.

Geretsried finally highlights the importance of concepts for the alternative use of initially unsuccessful wells. Within the CROWDTHERMAL RMC, we will present options for the re-use of (partially) failed wells.

4.2.3 The Risk Mitigation Experts' Perspective

Networking interviews on the subject of geothermal risk mitigation were conducted with key experts being involved in important past and ongoing risk mitigation schemes. While their expertise mainly stems from programs in East Africa, the majority of the lessons learned in that region can well be transferred to Europe.

Interviews were held with the following experts:

- Gordon Bloomquist, international geothermal expert and technical consultant to the GRMF
- Katrin Brandes, Senior Project Manager, KfW Development Bank (German Reconstruction Loan Corporation)
- Magnus Gehringer, CEO Consent Energy LLC, Consultant to World Bank Group
- Franca Schwarz, Head Sub-Department International Cooperation, BGR (Geological Survey of Germany)
- Meseret Zemedkun, ARGeo Program Manager (Regional Office for Africa), UNEP (United Nations Environment Programme)

The experts pointed out the following unaddressed or too weekly addressed issues in geothermal exploration risk mitigation (our comments in orange):

1) First of all, a geothermal law should be established since investors are more concerned about legal issues than about resource related risks.
   As examples of missing legal security are known to have prevented geothermal project developments in the past, this is an important unaddressed issue to be taken care of.
2) There should be a site-unspecific geothermal risk guide since former guides mainly focus on local or regional case studies which are not useful for the different specific problems which occur during project developments at individual sites.
   The online Risk Register that has been developed by the GEORISK project (compare to Section 4.1.4) can serve as a starting point for such a project-specific risk guide which will also be further considered in WP4.
3) There should be more focus on rental equipment not available to most of the project developers for logistic and/or economic reasons e.g. (i) downhole pumps for reliable well tests, (ii) facilities and different steel coupons for testing of corrosion and scaling, (iii) geophysical instruments for implementing surface studies.
   This is a very good measure to lower the risk and should be considered further. In addition to the given examples of loaned out equipment, we also suggest a mobile skid for on-site measurements of physicochemical parameters (heat capacity, viscosity and density) of the brine since standard values from steam tables will lead to an overestimation of the thermal capacity and related business plan (see Schröder et al. 2020, in review).

4) In Europe the surface exploration should not only consist of a seismic survey resulting in a geological model but should include geochemistry and hydro(geo)logy like already being established as international standard. The integrated data will result in a conceptual model implying a deep understanding of the underlying processes concerning the dynamic geothermal systems. The model may also include data not only from long-term well tests but also from a tracer test to assess the flow paths in the subsurface for an enhanced thermo-hydraulic modelling.
   The low-budget isotope geochemical surface exploration in Germany was introduced by the project TRACE (see Kraml et al. 2016) and is proposed as best practice.
5) The success of a geothermal risk mitigation instrument should be measured via the megawatts of thermal and/or electric capacity that were actually installed with the support of a respective scheme (compare to the request for performance indicators in Section 4.1.4). With this in mind, the risk mitigation scheme should either support/accompany the project until implementation or a range of support mechanisms should be available to account for the specific needs of all project phases.
   Even after a successful drilling of the first well, the challenge of follow-up financing remains, especially in countries with no or little experience in geothermal project implementation. We therefore suggest a concept giving support to all project phases (until implementation and beyond) for sustainable geothermal project development.[3] We thus propose to include a minimum of two wells and the long-term resource risk in the CROWDTHERMAL RMC.
6) In case of risk mitigation schemes only addressing surface exploration, the further prove of the resource with a successful exploration well producing steam or thermal water with sufficiently high flowrate would be a step further to attract investors.
   This is already an integral part of some risk mitigation schemes and could be covered by such schemes to be applied after resource assessment via surface studies schemes.
7) Collecting beforehand signatures from house door to house door for their commitment to the project until a certain percentage (e.g. 50 %) of the local people have agreed to it or even have shown their commitment. Then the opposition against the project can be handled more easily than currently often being the case, i.e. citizens' action groups cannot stop projects and a constructive dialogue can be started.
   WP1 and WP2 will specifically consider ways for social engagement and commitment. This aspect will therefore not be a special focus for the CROWDTHERMAL RMC.
8) The Government should drill and do the well testing to avoid any resource related risk for the investor. This would be a very direct measure compared to more indirect incentives like feed-in tariffs etc. currently applied e.g. in Germany and other European countries.
   This is indeed desirable, but associated with high public sector costs. We stress the need for a high governmental involvement in the funding of geothermal risk mitigation schemes. Successful examples of national governmental involvement in

[3] On this note, the GRMF is currently in discussion with financing institutions and donors in order to develop further financial instruments for the advanced project phases (Thinkgeoenergy 2020).

geothermal market support are e.g. the Philippines, where the national Energy Development Corporation (EDC) explored and developed many geothermal resources since the 1970s, paving the way for more and more private involvement (ESMAP 2016). National initiatives like the American Recovery and Reinvestment Act of 2009 with a significant budget for 'Energy efficiency and renewable energy research and investment' can also be important incentives for geothermal. A relatively low-cost support measure would be to enable the public access to subsurface data. Underground data e.g. from oil and gas exploration should be made publicly available for a limited charge after a certain embargo period (like in the Netherlands). This is for example envisaged by the new Geology Data Act (GeolDG) currently being in legislative process in Germany.

9) Concession areas should not be too small and too narrow to reduce the risk for reduced flowrate & temperature of the neighbouring concessions.
   We underline the significance of a robust conceptual model of the geothermal system as best practice. The conceptual model can help to define the suitable concession area for a geothermal project.
10) Small plants are not attractive for big investors.
   This is true but also small plants are very useful for rural electrification (mini grid) or local supply with heat for numerous direct use applications. Additionally, a small plant as first geothermal plant in a country can give confidence in this newly utilised renewable energy. We will consider all project sizes in the CROWDTHERMAL RMC.

4.2.4 The Insurance Companies' Perspective

In relatively mature geothermal markets as in parts of Germany and the Netherlands, a small number of geothermal project developers have had the possibility to successfully obtain private market-based exploration risk coverage from specialised insurance companies or brokers.

Unfortunately, the insurance company / insurance broker lead schemes were only partly successful (for details see Kreuter & Baisch 2018). Due to the general unfamiliarity of the insurance market with the nature of the risks of geothermal projects and sometimes problematically formulated coverage concepts, several projects had to be paid out (e.g. Traunreut 2012 and Geretsried 2013). Substantial loss had to be recorded by the insurances covering the projects. As a consequence, most insurance companies withdrew from covering geothermal projects.

Initiatives of several insurance brokers recently lead to a slow revival of private insurance schemes. There is however a large list of prerequisites for projects to be accepted by such schemes and there are high costs involved for the project developers. Generally, greenfield (no references) projects are not insured by private market-based schemes, because the risk to be borne is too high.

One of the main hurdles for a private market-based geothermal risk sharing industry is the limited number and small size of geothermal projects in less favourable Play Types[4] like they are for example present in Germany. The typical geothermal project in such regions – especially the direct heat applications which are expected to be the main focus of crowd-funded geothermal projects – is based on two wells, one for production and one for injection. As a consequence, exploration risk is focused on the success of these two wells and cannot be distributed over many wells. There is also a lack of institutions or developers being able to pool several projects in a portfolio approach.

In co-operation with WP2, we will discuss whether a portfolio approach could be envisaged by pooling crowdfunded geothermal projects. We stress the requirement for governmental involvement in geothermal risk mitigation in greenfield regions and less favourable Play Types with small project sizes.

Studies like the existing risk mitigation schemes benchmark summary (Boissavy 2019) indicate that low premiums in the range of 3 to 7 % are needed to have many subscribers to a geothermal risk mitigation facility. The perspective of the private insurance market as expressed at the GEORISK Workshop at the Praxiforum Geothermie.Bayern in Munich (7 October 2019) however was that even in regions like the Southern German Molasse Basin with a relatively well-known reservoir, this premium is extremely low and not risk adequate. A realistic number to attract insurance companies would lie at around 20 % premium level. One option would be to subsidise the high insurance premiums on the private market by governmental support programs with the aim of a high leverage of private capital relative to public capital. This mechanism is for example envisaged by the proposed GeoFutures Facility for East Africa (Robertson-Tait et al. 2017).

From the insurance industry's point of view, the drilling risk is an important factor for the risk evaluation of a project. Cost overruns while drilling can for example occur when drilling equipment is lost or stuck in the well requiring to drill side-tracks or even to abandon the well. The drilling risk can sometimes be covered by an EPC contract with the drilling operator (see below) or by a specialised broker, but many project developers face troubles finding risk coverage.

We will consider the risk of cost overruns while drilling in the CROWDTHERMAL RMC.

Representatives from insurance companies and brokers emphasise that the costs for e.g. expensive side-tracks or other measures to improve well productivity in case of (partial) failure are a significant financial burden for insurance companies (compare to the log file in Appendix 1). Consequently, these well improvement measures have a large impact on the level of insurance premiums. Mechanisms for a possible subsequent re-use of a dry well or

[4] Moeck and Beardsmore (2014) define a Geothermal Play as a model of a geothermal system classified on the basis of both structural position and geologic setting. The Play Type classification takes into account geological factors such as the reservoir rock unit, and properties such as the heat source, the dominant heat transport mechanism, a possible regional top seal or caprock and the geographic extent of the play.

the transfer of ownership of wells in case of (partial) project failure are currently hardly addressed.

In recent years, a new insurance concept led by a drilling company also active in geothermal project development has been offered to projects in Germany and the Netherlands. Besides the drilling company, the insurance model also involves an insurance broker and an insurance company. This risk mitigation model is also known as Alternative Risk Transfer (ART) mechanism or private-private partnership (see also Figure 2).

The EPC contract under this scheme includes the drilling of geothermal wells as well as an accompanying payback guarantee for the project developer in case the flow rate of a well does not meet an agreed threshold. Insurance against operating risks such as drilling risk, lost-in-hole, blow out, or environmental liability is also comprised.

The drilling company itself supplies a fund that pays a certain amount of money in case of project failure – if the deductible of the project developer is exceeded. The remaining part is provided by a reinsurance company co-operating with the drilling company. The fund is also fed by the premiums of the insured projects and royalties paid by successful projects which are insured by the scheme. In the event of a well failure entailing guarantee payout, a transfer of ownership of the unsuccessful well to the drilling company is foreseen.

One disadvantage of this insurance concept is the high premium of up to 25 % for the project developer and the considerable deductible that also has to be borne by the project developer. Furthermore, the concept of transfer of ownership raises a number of legal and property ownership questions, especially in the case of projects where one or more wells have been drilled successfully and a subsequent one being unsuccessful, thus transferred to the drilling company.

Since its establishment, the fund already had to pay out several guarantees. For this reason, it is currently not being offered as a standard to the geothermal industry.

Due to its complex and unique nature, the high costs for the project developer and the legal and organisational challenges regarding transfer of ownership of unsuccessful wells, we will not consider this insurance model further in the CROWDTHERMAL RMC. We will however follow the evolution of this new concept and its application in the geothermal industry.

Despite the limited success of the private schemes in the current market situation, substantial experience in structuring individual insurance situations was built up over time and new concepts were brought forward. These include improved ways for the “definition of success”, solutions for “partly successful” projects, non-claim repayments of the premium as well as the option to also include exploration and reservoir development costs or the option to limit coverage only to the drilling cost.

We will consider partly successful projects in the CROWDTHERMAL RMC and will give suggestions for the clear definition of success in an insurance contract.

Until now, private market-based insurance policies have not been offered to crowdfunded geothermal projects. Specific insurance companies might be interested in expanding their scope or even in investing in a geothermal risk mitigation facility as part of their climate strategy.

We will stay in contact with the private insurance market and discuss a possible adaptation of their insurance concepts to complement alternative financing methods. We will also explore the interest of the insurance market to invest in a possible new exploration risk mitigation scheme.

5 CONCLUSIONS AND FUTURE STEPS

Within CROWDTHERMAL's Task 3.1, GeoT and consortium partners liaised with various geothermal stakeholders in order to create a working cluster and to perform a demand analysis for geothermal risk mitigation in the context of alternative financing schemes.

More than 30 cluster dialogues were established with geothermal project developers, investors, co-operatives, past and ongoing exploration risk mitigation schemes and initiatives, the insurance market, geothermal and institutional experts, research projects, geothermal energy policy initiatives and public authorities.

As a result of the cluster analysis it can be stated that many efforts and initiatives exist aiming to mitigate the exploration risk of deep geothermal projects. Particularly the European H2020 project GEORISK currently works on the establishment of national exploration risk mitigation schemes in several target countries for which (international) replications are planned. Also, the funding of the French scheme GEODEEP supporting deep geothermal projects on mainland France has just been given the green light. What is missing however, is a pan-European exploration risk mitigation scheme as it has for example been envisaged by the project GEOELEC under the name of EGRIF. The biggest challenge for the establishment of such a pan-European scheme is to find financing sponsors.

During our demand analysis we identified many issues in geothermal risk mitigation that are not, not always or not sufficiently addressed. Not all of them are relevant to the context of CROWDTHERMAL. In the further course of WP3 we will focus on the aspects we consider as most important demands for geothermal risk mitigation in the context of alternative financing solutions and propose a framework for their mitigation.

Within the scope of Task 3.2 "Alternative finance risk mitigation" we will discuss tools that can increase confidence and credibility of a crowdfunded geothermal project towards all stakeholders, this being one unaddressed issue raised during the Case Study demand analysis. Possible examples are official sustainability certifications/concepts/labels, institutional match funding, patronage of well-known personalities from the renewable energy community and the involvement of geothermal experts. On these aspects, we will co-operate with WP1 and WP2. In collaboration with WP2, we will additionally discuss whether a portfolio approach could be envisaged by pooling crowdfunded geothermal projects in order to address one issue identified during the insurance market analysis. Task 3.2 will also include the analysis and summary of geothermal risk mitigation experts' opinion on alternative finance risks and their mitigation options as they were collected in the risk mitigation interviews.

Within Task 3.3 "Design of auxiliary and alternative pathways to risk mitigation" we will build on the results of GEORISK with regard to the most important risks to be addressed as well as the key factors of successful geothermal risk mitigation schemes (e.g. type of scheme, projects to be covered, premium and coverage ratios). We will align our framework to the one recommended by GEOELEC/EGRIF and will adapt their results to the context of CROWDTHERMAL.

The CROWDTHERMAL RMC will focus on the exploration risk i.e. the risk of not finding the economically viable amount of energy, defined by temperature and productivity of a geothermal reservoir of deep hydrothermal projects for a minimum of two wells per project. We will furthermore consider the scaling and other long-term operational risks (i.e. the risk of decreasing energy production e.g. due to declining flow rates or thermal break-through). The CROWDTHERMAL RMC will thus address both the short-term and the long-term resource risk in order to facilitate sustainable developments throughout all project phases, an issue which was brought up several times in the demand analysis. We will consider partly successful projects and present options for the re-use of (partially) failed wells. We will also give suggestions for the clear definition of success in an insurance contract. While it will not be our primary focus, we will still consider drilling risks and drilling-related cost overruns.

The cluster analysis confirmed that a new risk-sharing mechanism to complement alternative financing solutions should support different project and sizes and allow for site-specific characteristics in risk profiles. The CROWDTHERMAL RMC will therefore be a Play Type-independent scheme encouraging the development of geothermal projects of all resource types and sizes.

Especially the interviews with risk mitigation experts revealed the importance of a kind of geothermal risk guide for a sustainable geothermal project. We will therefore check the option to provide a roadmap to geothermal risk mitigation within the scope of Task 4.4.4 "CROWDTHERMAL Toolbox for risk-evaluation and mitigation". This roadmap is thought as an easy-to-understand guidance highlighting the most relevant risks and most important mitigation measures along the course of a project development. It will be oriented towards international best practice industry standards in geothermal project development. Certain contents of the DARLINGe tool-box (see Section 4.1.3) and the GEORISK GEOriskREPORT (see Section 4.1.4) could serve as blueprints for such a geothermal risk guide.

On the basis of the cluster analysis and given the market conditions currently present in most of Europe, we stress the importance of a high involvement of national governments or transnational financing bodies in the funding of a geothermal risk mitigation scheme. The need for a governmental role is especially large for poorly explored regions and less favourable Play Types with small project sizes. National governments could also play a role by funding a pool of rental equipment (e.g. downhole pumps, geophysical instruments, brine test facilities) to be available to all project developers. We finally highlight the importance of regulatory prerequisites like a geothermal law and public access to subsurface data for geothermal market uptake.

In the further course of WP3, we will continue the networking activities started in Task 3.1. In particular, we will monitor the work of the GEORISK project and consider the relevant results for the CROWDTHERMAL RMC. We will observe the progress of ongoing risk mitigation schemes as well as the evolution of newly launched or envisaged schemes like EGRIF, the GEODEEP fund and the GeoFutures Facility.

We will stay in contact with the private insurance market and follow the development of new concepts as well as their application in the geothermal industry. We will discuss a possible adaptation of private market-based insurance concepts to complement alternative financing methods and explore the interest of the insurance market to invest in a possible new risk mitigation scheme.

Finally, we will follow the progress of WP1 and WP2 and their strategies to address environmental risks and the risk of low social acceptance in order to identify any possible implications for WP3.

As the next step, the results of this Deliverable 3.1 will be presented and discussed with the members of the Advisory Board at the CROWDTHERMAL Consortium / Advisory Board Meeting on Gran Canaria on 18.03.2020. The remarks of the Advisory Board will be taken into account for the future work within Tasks 3.2 and 3.3.

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APPENDIX 1

Cluster Dialogues Log Sheet

CROWDTHERMAL - WP3
Risk Mitigation Clusters and Dialogues

Contact ID	Name of project/ platform/company	Type of project/ platform/company	Focus of project/ platform/company	Status of project/ platform/company	Contacted by (Institution)	Contacted Institution	Possible Synergies for CROWDTHERMAL	First ideas demand analysis geothermal risk mitigation	Unadressed issues in geothermal risk mitigation	Comments
1	GEORISK / (EGEC)	H2020 R&D Project	Establishment of geothermal Risk Mitigation Schemes across Europe	ongoing	GeoT / EFG	EGEC	GEORISK risk inventory, risk assessment, online risk register, existing Risk Mitigation Scheme (RMS) benchmark study, key factors of RMS, framework for new national RMS	The GEORISK risk assessment (D2.2) summarizes which risks are seen as the most relevant ones in the stakeholder analysis for the GEORISK target countries	In the first WPs, GEORISK considers all risks in geothermal. The risk mitigation schemes to be established focus on the geological risk.	Consortium members were invited to create synergies between our two projects and to share their ideas with the CROWDTHERMAL team. Good working link via GeoT and gec-co, as they are both involved in both projects (subcontractors). Oral presentation at GEORISK consortium monthly call and CROWDTHERMAL press release sent to consortium email-list.
2	Munich RE	Insurance Company	Private market-based insurances	ongoing	GeoT	Munich RE	Experience with private market-based exploration risk insurance policies in Germany, USA, East Africa, Turkey, also with public-private partnership risk mitigation schemes (Germany), experience with portfolio approach	Small projects (less favorable Play Types) / Greenfield (no references) projects are not insured	Mechanisms for subsequent re-use / transfer of ownership in case of (partial) project failure are not addressed. Costs for e.g. sidetrack / measures to improve well productivity in case of (partial) failure are financial burden for insurance companies.	Part of GEORISK Advisory Board. Munich RE might be interested in adapting their insurance concept / solution to complement alternative financing methods. Might be considered as investor of possible new RMS.
3	Axa	Insurance Company	Private market-based insurances	ongoing	GeoT	AXA-MATRIX	Experience with private market-based (exploration) risk insurance policies for geothermal projects in Germany		Mechanisms for subsequent re-use / transfer of ownership in case of (partial) project failure are not addressed. Costs for e.g. sidetrack / measures to improve well productivity in case of (partial) failure are financial burden for insurance companies.	Part of GEORISK Advisory Board. Axa might be interested in adapting their insurance concept / solution to complement alternative financing methods. Might be considered as investor of possible new RMS.
4	NW Assekuranz	Global Insurance Broking	Private market-based insurances	ongoing	GeoT	NW Assekuranzmakler ProRisk GmbH & Co. KG	Experience with private market-based (exploration) risk insurance policies for geothermal projects in Germany			Might be interested in adapting their insurance concept / solution to complement alternative financing methods.
5	Swiss Federal Office of Energy (SFOE)	Public authority	Administration of Swiss State Risk Mitigation Scheme for Geothermal	ongoing	GeoT	Swiss Federal Office of Energy (SFOE) / Bundesamt für Energie (BFE)	Experience with past and ongoing public risk mitigation schemes in Switzerland	The new Swiss State RMS also supports greenfield projects with large-scale exploration grants		Part of GEORISK consortium. Very knowledgable and interested in our project.
6	GRMF	Risk mitigation scheme	Risk Mitigation Scheme for Geothermal in East Africa	ongoing	GeoT	Freelancer	Experience with GRMF and numerous other risk mitigation schemes: e.g. WB project insurance for Central and Eastern Europe	Scaling & corrosion and the surface studies should be addressed/done properly (conclusive conceptual model). Funding should also include an interference test, tracer test and numerical reservoir modelling.	Loaned out equipment for pumping tests and for testing of corrosion and scaling, geophysical instruments for surface studies etc.. There should be a detailed Geothermal Risk Guide. First establish a geothermal law.	Silica removal is solved; a new binary plant with 40 % higher efficiency exists. Heat projects and extraction of valuable elements should not be neglected. A well planned project and related fast project implementation are rare.
7	ARGeo	Risk mitigation scheme	Risk Mitigation Scheme for Geothermal in East Africa	ongoing	GeoT	UNEP	Experience with ARGeo Risk Mitigation Scheme dealing with Exploration Risk in the East African Rift System	Data base with exploration results for investors; technical assistance until final conceptual model of specific geothermal sites (pre-feasibility study with resource potential); geophysical instrument pool for member countries stored and maintained in Kenya; platform ARGeo conference for regional exchange of experiences; Critical mass of homegrown experts (AGCE = African Geothermal Center of Excellence => capacity building); Technical review meeting e.g. on bottleneck western branch: low temperature; eastern branch: high temperature => game changer to revise policy guidelines for direct use to facilitate projects in the western branch; Secure funds via GRMF (KfW)	The MW installed capacity is what counts (is not yet achieved via ARGeo)	Status of Ngozi project: they will drill slim holes funded by AfDB. Other mature ARGeo projects are Silali, Kenya and Kibiro, Uganda
8	GEOTHERM / (BGR)	Programme of Geological Survey of Germany	Technical cooperation in geothermal exploration	ongoing	GeoT	BGR	see Franca Schwarz	see Franca Schwarz	see Franca Schwarz	see Franca Schwarz
9	BGR	Geological Survey of Germany	Technical cooperation in geothermal exploration	ongoing	GeoT	BGR	see Franca Schwarz	see Franca Schwarz	see Franca Schwarz	see Franca Schwarz
10	BGR	Geological Survey of Germany	Technical cooperation in geothermal exploration	ongoing	GeoT	BGR	GEOTHERM programme and bilateral geothermal projects of BGR, Hannover Germany	A well-established information base of geoscientific data of the to-be-explored site. However, each site is different and hence, comes with different risks.	The prove of the resource with a successful exploration well producing steam or thermal water with sufficiently high flowrate.	no additional comments
11	KfW	Development bank	Financing of geothermal projects and risk mitigation schemes	ongoing	GeoT	KfW development bank	Experience with GRMF design	Social acceptance / NIMBY projects	Collecting beforehand signatures from house door to house door for their commitment to the project until a certain percentage (e.g. 50 %) of the local people have agreed to it or even have shown their commitment	Consider allowing contributions at a low level. Ask for public match funding. This also proves the ownership of the project and it mitigates the risk of project failure later on due to non-acceptance of the local community/municipality etc.
12	former WB consultant	Consulting company	Mitigation of risks during geothermal project development	ongoing	GeoT	Consent Energy LLC	GeoDeep project in France; Caribbean Risk Mitigation Fund; Geothermal strategy for Kenya and Ethiopia; Interim manager of GRMF; Policy training for Department of State, U.S.A.	PPA, drilling insurance, and solid legal framework in place at the beginning of the project. Additional incentives should be available and the possibility for a PPP with the government given.	Government should drill and do well testing => +/- no resource risk. Concession areas should not be too small and too narrow => risk for reduced flow rate / temperature and small plants are not attractive for big investors.	The geothermal community needs to promote the advantages of geothermal energy also compared to other RES i.e. full calculation of the levelized costs considering all externalities => geothermal is competitive.

13	former Worldbank expert	Bank, Energy Specialist, Energy & Extractives Global Practice	Renewable Energy team / Global Geothermal Development Plan	ongoing	GeoT / GEORG	Worldbank	no response	no response	no response	no response
14	Worldbank	Bank	Financing of geothermal projects and risk mitigation schemes	ongoing	GeoT	Climate Policy Initiative	no response but publication available	no response but publication available	no response but publication available	no response but publication available
15	innova eG	Registered cooperative	Founding of energy cooperatives	ongoing	GeoT	innova eG	Successful crowdfunding for energy project	not applicable since it was no geothermal project	not applicable since it was no geothermal project	The best organization form for crowdfunding in Germany is the registered cooperative. The persons in the board should have the necessary qualification. The financial risk sharing should be done via a "qualified subordinated shareholder loan". The high degree of trust in the integrity of the board members is a prerequisite. Include a well-known testimonial of the renewable energy community.
16	S4CE - Science for Clean Energy	H2020 R&D Project	Quantification and reduction of environmental impacts of geo-energy operations	ongoing	GeoT	University College of London	Research-based approach to predict, detect and monitor possible sources of environmental contamination of geo-energy operations. LCA and environmental impact assessment, multi-risk assessment, animated video production "No risk - no energy", contact to UDDGP			Crowdthermal Press Release was shared with project and communication manager and posted on S4CE webpage as news. GeoT is part of the consortium.
17	MEET - Multi-sites EGS Demonstration	H2020 R&D Project	Boosting the development of Enhanced Geothermal Systems (EGS) across Europe in various geological contexts (sedimentary, volcanic, metamorphic and crystalline) by different means	ongoing	GeoT	Ayming	Risk assessment for chemical stimulation operations, contact to UDDGP			Crowdthermal Press Release and information was shared with the entire consortium. GeoT is part of the consortium.
18	DARLINGe	INTERREG Danube Region project	Increasing the penetration of geothermal in district heating	completed	SZDH	InnoGeo Research and Service Nonprofit Public-benefit Ltd	Experience with past and ongoing public and private risk mitigation schemes in Hungary, Serbia, Romania and Slovenia		Mitigation of risks related to operations (e.g.: scaling, clogging in injection wells, pipelines)	The DARLINGe consortium developed geological risk mitigation schemes for three pilot areas in South-East Europe (HU-RO-SRB, SLO-HU-HR, BH-SRB). Part of this is accessible online as a risk mitigation tool-box and might serve as blue-prints for CROWDTHERMAL.
19	GEOTHERMICA	H2020 R&D Project	Geothermal Energy Policy	ongoing	GEORG		Project database and collaborated national funding bodies have information, good practices and knowledge on the evolution of national funding environments, national barriers, opportunities and research. It can ensure the a good input of information	No risk assesment work package in particular example, but a significant resource of collaboration and work based also on the www.geothermaleranet.is; Collaboration with European Geothermal Risk Insurance Fund (EGRIF)	Improve the financial risk funds / loans for geothermal exploration and first drilling	Experienced partners in risk assements in the project associateed with techno-economic implementation associated with funded projects. Aims at the reduction of costs, minimization of exploration and exploitation risk and develop ways to sustainable reservoir use.
20	IWG-DG	H2020 CSA Project	Geothermal Energy Policy	ongoing	GEORG		Promote and organise initiatives to mobilize growth of and implementation within the geothermal community, e.g.: workshops, brokerages, consortium building and exploitation of RD&I results	One of the targets set in January 2018 were to coordinate national geological risk mitigation methods and financial schemes		
21	GEOENVI	H2020 R&D Project	Environmental Assessment of Geothermal Energy	ongoing	GEORG		GEOENVI risk assessment, stakeholder analyses, data base, LCA analyses. One main result will be the development of a simplified methodology for the life cycle assessment of geothermal projects to be available to project developers. The life cycle assessment guidelines shall help to monitor project risks throughout all project phases and include tools to mitigate environmental risks.	The GEOENVI risk assessment summarizes which risks are seen as the most relevant ones in the stakeholder analysis for the GEOENVI target countries	All stakeholders must be informed about risks and opportunities.	Part of the GEOENVI consortium is involved in the CROWDTHERMAL project. The GEOENVI project will also be considered in the context of WP1 by UoG.
22	DGE-ROLLOUT	Interreg Northwest Europe Project	Facilitating Deep Geothermal Project Development in Northwest Europe	ongoing	EFG	Royal Belgian Institute of Natural Sciences Geological Survey of Belgium	Project is working on risk mitigation for geothermal developments in NW Europe by better exploration and providing 3D geological data basis. Similar to CROWDTHERMAL, DGE-Rollout also plans to launch an online tool.	Limited availability of geological data		Estelle expressed interest for clustering activities. GeoT is also part of the consortium as sub-contractor.
23	REFLECT	H2020 R&D Project	Chemical Risks	ongoing	EFG	GFZ				EFG is partner in this project and has sent information about CROWDTHERMAL and the GeoT Risk Mitigation Questionnaire.
24	GeoERA	Public authority	Geological Surveys	ongoing	EFG	Austrian Geological Survey				Contact between Gregor Götzl and GeoT was established and the GeoT Risk Mitigation Questionnaire was sent. Mr. Götzl will contact local projects in Vienna to reply to the questions in Januay 2020.
25	ETIP-DG	European Platform		ongoing	EFG					EFG has sent information about CROWDTHERMAL and the GeoT Risk Mitigation Questionnaire.
26	State Supervision of Mines (SSM), Netherlands	Public authority	Ultra-Deep Geothermal		EFG					EFG has sent information about CROWDTHERMAL and the GeoT Risk Mitigation Questionnaire.

27	SZETÁV	Project Developer / Investor	District Heating Project in Szeged, Hungary	ongoing	GeoT	SZETÁV	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.
28	Arroyo Bodonal	Co-operative	Residential buildings co-operative	completed	geoplat		See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.
29	EAI 310	Co-operative	Residential buildings co-operative	completed	geoplat		See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.
30	EIMUR	Project Developer / Investor	Greenhouse Project in Húsavík, Iceland	ongoing	GeoT	EIMUR	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.	See full-length Case Study questionnaire in Appendix 3.
31	HotRock GmbH	Project Developer	Drilling of dry well Offenbach an der Queich, Germany	completed	GeoT	Formerly HotRock GmbH, now GeoThermal Engineering GmbH	Lessons learned from a failed project with a dry well.	Public exploration risk mitigation schemes for geothermal project developers	Re-use concepts of (partially) failed wells	Apply best practice industry standards for exploration. Include contingencies in drilling planning and budget.
32	Projektgesellschaft Enex Geothermieprojekt Geretsried-Nord GmbH & Co KG	Project Developer / Investor	Drilling of dry well Geretsried, Germany	ongoing	GeoT	Projektgesellschaft Enex Geothermieprojekt Geretsried-Nord GmbH & Co KG	Lessons learned from a failed project with a dry well	The involvement of national governments and public money in risk-sharing for geothermal projects as key prerequisite for market uptake	Infrastructure costs not covered by insurance policies. Concepts for the alternative use of initially unsuccessful wells.	Geothermal developments involve a large and often incalculable financial risk. This needs to be taken into account when envisaging community-based financing for early development phases of a geothermal project.

APPENDIX 2

Demand Analysis Risk Mitigation - Risk Mitigation Experts Questionnaire

WP3 – TAKS 3.1

DEMAND ANALYSIS RISK MITIGATION

RISK MITIGATION EXPERTS QUESTIONNAIRE

1) Your experience with geothermal risk mitigation scheme(s)?

2) Your ideas for a demand analysis in geothermal risk mitigation (regarding resource-related risks)?

3) Are there any "unaddressed issues in geothermal risk mitigation"? (If this so far unaddressed issue would be covered, the projects – or more projects – could be implemented)?

4) Do you think that additional crowdfunding or financial participation of many small investors could be beneficial for initiating geothermal projects or for their implementation?

5) Can you think of new risks associated with that alternative financing scheme?

6) Do you have any further comments?

APPENDIX 3

Demand Analysis Risk Mitigation - Case Study Questionnaires

WP3 – TASK 3.1

DEMAND ANALYSIS RISK MITIGATION – CASE STUDY QUESTIONNAIRE

SZEGED, HUNGARY

SZETÁV

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 857830.

DEMAND ANALYSIS RISK MITIGATION – CASE STUDY QUESTIONNAIRE

1. Please describe your case study project in three sentences.

The District Heating Co. of Szeged (SZETAV) and its consortium partners secured 45% EU funding for a large-scale project totalling at 70M Euro's to reduce the emissions of 9 of the 23 currently gas-powered heating circuits in Szeged, and to improve their economy with the help of geothermal energy. During the project 1,700 - 2,000 m deep thermal wells (9 production and 18 injection) are drilled producing 70 m3 / h thermal water at 90oC. As a result of the project, nearly 20 million m3 of natural gas will be replaced with 600,000 GJ of geothermal energy annually, reducing the greenhouse gas load of the city of Szeged by 35,000 tons / year, improving air quality and security of supply.

2. Who are the main risk owners of your project?

The project owner is the consortium of a private project-enterprise (GeoHőterm Ltd), a state-owned non-profit responsible for management and public procurement (NFP Ltd.) and the municipally owned SZETAV Ltd. GeoHőterm may be considered the main risk owner as they are contractually responsible to provide the necessary amount of thermal water for SZETAV so that the latter can run the 9 heating circuits on geothermal once the project is completed, therefore the physical completion of the main parts of the project (wells, well-heads, pipelines) is their responsibility. SZETAV is responsible to make modifications to its heating centres so that they can be run on geothermal. Nevertheless, since SZETAV is a well-known company in Szeged providing heat to half of the city and the project as a whole is generally associated with SZETAV most public complaints are addressed to us, delays, minor or major disturbance of the locals let alone a failure of any kind will be seen as our fault.

3. What do you consider the major overall risks of your project?

Drilling 27 wells without any problems would be nothing short of a miracle. The company contracted had already drilled 6 wells in Szeged and while the drillings were successful, most if not all of them suffered delays. There is no insurance policy available for drilling companies to mitigate drilling risks. I happened to the project-manager of the geothermal district heating development in Makó (a town nearby Szeged) where an insurance company had to pay 300,000 Euro's to cover a drilling accident and since then no insurance company covers drilling. Szeged is densely populated – drilling is noisy, there are already many people complaining and even national media picked up the issue of us drilling too close to homes. If some drillings are unsuccessful, it will be hard if not impossible to find new locations for drilling. Laying pipelines under major roads, tram-lines etc is risky too, cutting through existing sub-surface infrastructure will cause major inconvenience for the locals. Switching a heating centre from gas to geothermal requires time – people without heating or domestic hot water mean people complaining in the newspaper. During operation scaling will be a serious issue – scaling can kill pumps and other equipment worth tens of thousands of Euro's, so a complex water treatment plan needs to be drafted once the eater samples are in and implemented.

4. What do you consider the major risks of your project associated with the geothermal resource?

The upper Pannonian Sandstone reservoir under Szeged is a fairly safe bet for finding water, still, the exact temperature and amount of water that will be available for production at each well and, conversely the capacity of the aquifer at the injection wells for reinjection are only known once the wells are completed. We don't expect wells to be completely "dry" wells but cooler temperatures from production wells or higher pressure needed for injection are very much possible. Also, mechanical failures or other technical problems during drilling are quite possible.

5. What do you consider the major risks of your project associated with alternative financing solutions and/or public engagement?

The project is financed from private investment and EU money. There is no alternative financing involved. Public engagement has its fair shares of issues already. People complain about the noise of drilling and this is only the first 2 wells, there will be 16 more. Given that there will be no price cuts in the heating bills, the cleaner air is the only upside of the project for them, which is important but harder to sell than cheaper heating. A more coordinated and professional information campaign would be needed but the technical elements of the project overwhelm the experts involved.

6. Who do you consider potential risk mitigation helpers of your project?

The City Hall is 100% behind the project, making Szeged the "greenest" city in Hungary is the new slogan of the major, so they can help in communicating with people. The Institute of Geosciences of the local university gives advise during drilling and will continue advising during operation.

7. Which risk mitigation strategies have you already implemented or do you plan to implement during the course of the project?

There is a very basic risk mitigation strategy to be included in the feasibility studies of geothermal projects but it's not something that is taken very seriously. I don't think it even counts as a real strategy.

8. Which risks are currently not mitigated and missing possibilities to mitigate them?

Since there is no insurance for drilling, unplanned incidents during drilling can put the whole project in danger. Better communication would go a long way too. Also, more experienced drilling crews would be needed for specialised tasks (cementing, screening) but that costs a lot of money and with geothermal drilling at its peak in the region it is unlikely that they can get higher trained personnel than they already have.

9. Which is your most important request to be considered by an auxiliary risk mitigation solution to be drafted within the CROWDTHERMAL project?

Mitigating risks of drilling, engaging the public.

10. Please list any additional comments you might have.

I doubt public financing is an option in the Szeged case (although it can be studied) but strategies to engage the public would be very welcome. Mitigating risks of drilling would be important but I don't really see how if insurance policies are non-existent.

CROWDTHERMAL

WP3 – TASK 3.1

DEMAND ANALYSIS RISK MITIGATION – CASE STUDY QUESTIONNAIRE

ARROYO BODONAL, MADRID, SPAIN

geoplat

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 857830.

DEMAND ANALYSIS RISK MITIGATION – CASE STUDY QUESTIONNAIRE

1. Please describe your case study project in three sentences.

- In 2003 a group of young people from Tres Cantos (Madrid) decided to create a cooperative with the aim of promoting the construction of residential buildings with the highest degree of efficiency and energy savings, as well as the use of alternative energy. The project was planned in 2009 when they bought the land. In 2012 the project started and it completely finished at the end of 2014. Houses were handed over in the middle of 2015.
- "Edificio Arroyo Bodonal" is a sustainable construction and energy efficiency project that provides heating, cooling and domestic hot water to 80 houses in Tres Cantos (Madrid), with up to 80% savings in energy consumption, thanks to the use of geothermal heat pumps (shallow geothermal system) and the integration of ventilation equipment with heat recovery. The building obtained the LEED Platinum certification in 2016.

2. Who are the main risk owners of your project?

- The **members of the cooperative** (approximately 80 members), current owners of the houses. The project has been entirely financed by the members.

3. What do you consider the major overall risks of your project?

- **The lack of credibility:** the lack of credibility on the part of entities (financial, town councils, construction company) greatly hindered the granting of permits and the development of the project in general. The subcontractors tried to lower the price by saving on qualities and cheaper installations, but the cooperative stayed in its position.
- As the cooperative and the architect were fully convinced, the main risk was to obtain financing (credit) for the project as well as to find a construction and installation companies willing to carry out the project without changing it. The lack of financing or subcontracted companies would have delayed the project more than it was.
- The project has been entirely financed by the members, thanks to a credit finally obtained through Triodos Bank. This was the only entity that agreed to finance this project.

4. What do you consider the major risks of your project associated with the geothermal resource?

- As it was a shallow geothermal energy project with a closed system, so **there was no risk** associated with the geothermal resource as the system is always viable.

5. **What do you consider the major risks of your project associated with alternative financing solutions and/or public engagement?**
   - **The lack of credibility:** The major risk regarding the financing solution was to **find an entity willing to help the cooperative**. The project wasn't trustful for some entities, and finally, after negotiations, just Triodos Bank was willing to grant credit to the cooperative. The lack of credibility on the part of entities (financial, town councils, construction company) greatly hindered the granting of permits and the development of the project in general.
   - There were no risks associated with public engagement, as the geothermal integration was planned and agreed from the beginning within the cooperative members.

6. **Who do you consider potential risk mitigation helpers of your project?**
   - **The cooperative as a whole:** The commitment of the members allowed to take the project to the end without making changes on it, in spite of the difficulties and the attempts to modify it.
   - The **architect** and the final construction company of the project. The architect had worked with geothermal before, and he was a great help in preparing the project and getting involved in it. Finally, the chosen construction company understood the geothermal requirements and specifications and didn't try to change the heating system of the building.

7. **Which risk mitigation strategies have you already implemented or do you plan to implement during the course of the project?**
   - **The commitment of all cooperative members (total confidence in the initial project):** Although several intermediaries involved in the development of the project tried to save money proposing cheaper and lower quality systems, the cooperative maintained its position on using a high-quality geothermal system along with other sustainable construction specifications. The integration of the geothermal system was planned for the beginning of the project, so it wasn't possible to make changes to it.
   - **LEED certification:** Obtaining the LEED certification was a clause in the contract with TRIODOS, the financing entity. When the project was negotiated, the financing entity asked the promoters for a tool to evaluate the success of the project. As there was no official certification of sustainable buildings in Europe, they decided to use the American LEED certification as a proof of efficiency and sustainability. They finally got the LEED Platinum certification, which entails the maximum punctuation.

8. **Which risks are currently not mitigated and missing possibilities to mitigate them?**
   - Because of the geothermal system used, there are no technical risks ahead. The cooperative members are still paying the mortgage loan, but **no further risks** are considered for this project. They are satisfied with the result of the project.

9. **Which is your most important request to be considered by an auxiliary risk mitigation solution to be drafted within the CROWDTHERMAL project?**
   - Some **tool that guarantees confidence and credibility** in the geothermal project on the part of all project stakeholders (investors, financial entities, subcontracted companies).

10. Please list any additional comments you might have.

- The biggest problem they found to carry out the project was the lack of trust and credibility on the part of financing entities and construction companies. From 2003 to 2012, when the project started, sustainable buildings projects, including geothermal ones, were not so extended in the country. However, having an architect with experience in this type of projects helped a lot to encourage the different entities to collaborate in the project. <u>It's very important to count on experts to justify the convenience of a project.</u>
- Furthermore, the geothermal part should be considered from the beginning of the project, so it's fully integrated and justified in the general plan and can't be modified afterwards. During negotiation processes, changes in the project related to de H&C systems were proposed to the members of the cooperative several times.
- The economic inequality was raised during the interview. Not all communities have the financing capacity to participate in this kind of projects and these projects shouldn't cause distrust in neighbour communities.

WP3 – TASK 3.1

DEMAND ANALYSIS RISK MITIGATION – CASE STUDY QUESTIONNAIRE

EAI 310, MARDID, SPAIN

geoplat

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement nº 857830.

DEMAND ANALYSIS RISK MITIGATION – CASE STUDY QUESTIONNAIRE

1. Please describe your case study project in three sentences.

- The cooperative EAI310 was founded in 2012, after a group of parents joint and decided to bid on an urban plot of land and build a housing block for their families. The building work began in November 2013 and the houses were handed over in December 2015.
- EAI310 consists of 220 dwellings distributed in several buildings. The project was planned under the Trias Energetica concept. The H&C system is bivalent. On the one hand, the geothermal system designed consisting of a closed vertical system of very low enthalpy in combination with heat pump provides baseload and provides heating, cooling and even domestic hot water. On the other hand, the demand peaks are covered with a conventional system (boilers and chiller).

2. Who are the main risk owners of your project?

- The **<u>members of the cooperative</u>** (approximately 200 members), current owners of the houses. The project has been entirely financed by the members.

3. What do you consider the major overall risks of your project?

- **<u>Attempts to change plans or qualities</u>** by intermediaries in several stages of the project: The subcontractors tried to lower the price by saving on qualities and cheaper installations. However, the cooperative had a clear idea of what they wanted and they maintained their position.
- The integration of the geothermal system into the H&C system and the achievement of good performances, as well as the realization of the drilling works within the building plot.

4. What do you consider the major risks of your project associated with the geothermal resource?

- As it was a shallow geothermal energy project with a closed system, so **<u>there was no risk</u>** associated with the geothermal resource as the system is always viable.

5. What do you consider the major risks of your project associated with alternative financing solutions and/or public engagement?

- There were **<u>no risks</u>** associated with public engagement, as the geothermal integration was planned and agreed from the beginning within the cooperative members.
- Regarding financing issues, the project has been entirely financed by the members. The cooperative exposed the case to the bank, which granted individual mortgages to each of the owners (cooperative members).
- The only issue related to the investment were the efforts of subcontractors to reduce project costs. The reductions in costs meant using lower quality material, machinery

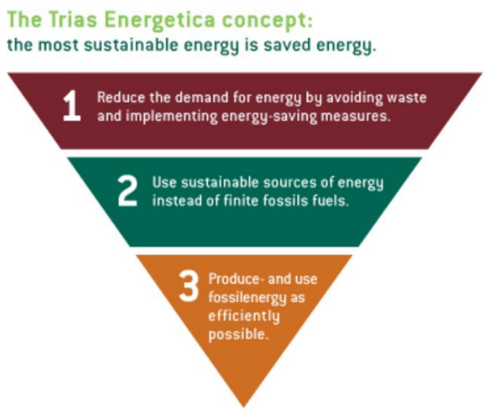
or untrained personnel. As the whole cooperative had a clear vision of what they expect from the project, including the geothermal system within the Trias Energetica concept, finally no changes were made in the plan.

6. Who do you consider potential risk mitigation helpers of your project?

- **The cooperative as a whole:** The commitment of the members allowed to take the project to the end without making changes on it, in spite of the difficulties and the attempts to modify it.
- An **expert or consultant with deep knowledge on geothermal** and the project itself as well as the minimum performance required, who is able to defend and stand for cooperative members' interests during the whole project.

7. Which risk mitigation strategies have you already implemented or do you plan to implement during the course of the project?

- **The commitment of all cooperative members (total confidence in the initial project):** Although several intermediaries involved in the development of the project tried to save money proposing cheaper and lower quality systems, the cooperative maintained its position on using a high-quality geothermal system along with other sustainable construction specifications. The integration of the geothermal system was planned for the beginning of the project, so it wasn't possible to make changes to it.
- **Trias Energetica:** The whole project followed the Trias Energetica model, ensuring the sustainability of the whole residential block. As this model was the base of the whole project, the integration of the geothermal system was immovable for cooperative members.



8. Which risks are currently not mitigated and missing possibilities to mitigate them?

- Because of the geothermal system used, there are no technical risks ahead. The cooperative members are still paying the mortgage loan, but **no further risks** are considered for this project. They are satisfied with the result of the project.

9. Which is your most important request to be considered by an auxiliary risk mitigation solution to be drafted within the CROWDTHERMAL project?

- Some **element that avoids attempts to change the H&C system** of the project for a cheaper one: The main problems they found were related to subcontractors trying to reduce qualities to reduce cost. The cooperative has been struggling with this throughout the whole project.
- Some **tool that guarantees confidence and credibility** in the geothermal project on the part of all project stakeholders (investors, financial entities, subcontracted companies).

10. Please list any additional comments you might have.

- Related to the cost reduction by saving in qualities and installations, the cooperative members understand the cost is not so high when talking about comfort. The comfort obtained thanks to a geothermal system is not similar to those obtained with conventional systems. Geothermal integration is not so costly if you think about it from the comfort point of view.
- Geothermal system to be considered from the beginning of the project as part of the H&C system, not as an external element.
- The importance of the figure of an expert geothermal consultant.

WP3 – TASK 3.1

DEMAND ANALYSIS RISK MITIGATION – CASE STUDY QUESTIONNAIRE

HÚSAVÍK, ICELAND

EIMUR

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 857830.

DEMAND ANALYSIS RISK MITIGATION – CASE STUDY QUESTIONNAIRE

1. Please describe your case study project in three sentences.

The case study is aimed at being a showcase for direct use and the possibilities behind geothermal utilization. The case study will be on the form of a community greenhouse in the town of Húsavík. The greenhouse will be split into three parts, one for the community, where public, businesses and schools for example can rent a slot to grow vegetables, fruits, herbs and so on and make small scale experiments for themselves. Another part will be a laboratory, closed for public, where bigger members can experiment with more sensitive plants on a small scale. The third part will be on the form of a commercially driven restaurant where the ingredient are grown at site. This is thought of as a show case for the vast number of tourists visiting Húsavík each year.

2. Who are the main risk owners of your project?

Risk owners are the ones that fund the project, there is a possibility that it will not be able to become a sustainable business financially or give back what's expected. The municipality is also a risk owner as the facility is supposed to be used for teaching and growing vegetables for schools. The members that take part in the second part of the greenhouse with small scale experiments on more sensitive production. Owners of the resources, such as the water and energy. However the commercial relationship between resource owners and the project is currently under development.

3. What do you consider the major overall risks of your project?

The major overall risk is the funding. How to get the crowd to care and how to get people and businesses involved and willing to fund the project. If the project will get funded and a community greenhouse will be built the risk will be to keep those involved interested and involved for the long term as well to develop a business model that can be viable over the long run.

4. What do you consider the major risks of your project associated with the geothermal resource?

The resource itself has been utilized for over a century in the area and its capacity is well defined. However among the owners of resources is a small farming community, that possibly might consider this project as a competition.

5. What do you consider the major risks of your project associated with alternative financing solutions and/or public engagement?

Case study not presented well enough to the public.

The local municipality elections, new elected members possibly with a different vision towards the project compared to the current ones.

Light pollution, since the area is popular among tourists looking at the northern lights.

Too high CAPEX compared to the investment capabilities in the area.

Financing model too complex or not appealing enough for the general public.

6. Who do you consider potential risk mitigation helpers of your project?

Strong involvement by the local municipality.
Professional help with PR campaign and public outreach.
Explore the potential of light blocking curtains during nights.
Upfront estimation of maximum CAPEX threshold for the case study.

7. Which risk mitigation strategies have you already implemented or do you plan to implement during the course of the project?

The project is in early stage of development and no such strategies have been implemented.

8. Which risks are currently not mitigated and missing possibilities to mitigate them?

Local producers looking at the case study as a potential competition.

9. Which is your most important request to be considered by an auxiliary risk mitigation solution to be drafted within the CROWDTHERMAL project?

How to involve local farmers and producers.

10. Please list any additional comments you might have.

N/A