CROWDTHERMAL

CROWDTHERMAL DELIVERABLE D5.1

CASE STUDY ASSESSMENT PROTOCOL

Summary:

CROWDTHERMAL aims to study the necessary conditions for the development of community-based financing geothermal projects, focusing on social aspects rather than technical. For that reason, a customized protocol for assessing all involved actor's perception of the process, concerns and needs, public acceptance and participation issues, has been developed within the project.

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1 EXECUTIVE SUMMARY

Public perception influences geothermal projects either directly, in the form of local action groups, or indirectly, by defining the political climate for geothermal energy production. The satisfaction of costumers is a good precedent to increase the acceptance of RES these projects. Building up the public perception and acceptance of these projects is more and more important to speed up their development. This is essential also because energy is one of the most important factors for economic development and the competitiveness of the European economy. Public acceptance and stakeholder management are becoming increasingly important issues for successful geothermal development.

Alternative finance, specifically community finance mechanisms such as crowdfunding within a local community, has become very successful in attracting large amounts of risk capital and loans in all types of projects. This type of finance sets the consumers at the center of the action, providing them the capacity to make decisions about the project. CROWDTHERMAL project encompasses three alternative financing case studies to be analyzed to study the perception of the public involved in those projects.

CROWDTHERMAL aims to study the necessary conditions for the development of community-based financing geothermal projects, focusing on social aspects rather than technical. For that reason, a customized protocol for assessing all involved actor's perception of the process, concerns and needs, public acceptance and participation issues, has been developed within the project. Not all case studies are subject to the same conditions and risks, but the protocol needs to adapt to the different types of geothermal projects. It will enable the generation of an acceptance profile for each case study through the assessment of project performance and public perception about important topics (risk, environmental, social, institutional and economic indicators).

The protocol is composed of several stages, enabling both the characterization and the assessment of the perception of the project by the involved public in each case study. One first stage consists of the general characterization of the project. It includes geographical, technical, socioeconomic (including finance) and environmental aspects. The second and third stages consist of two different surveys, which tackle public awareness (knowledge) and perception of geothermal projects.

To obtain a complete and tailor-made protocol, this Case Study protocol has been designed in synergy with WP1, WP2, and WP3, integrating public awareness/perception, risks mitigation and financial aspects. The results of the protocol will be further analyzed and will support the development of WP1-WP3 concepts, feeding the work that will be developed in WP4.

2 INTRODUCTION

Increasing the share of renewable energy is high on the policy agenda in several European countries and the EU as a whole[1] to reach the objective of decarbonizing the energy system[2]. The implementation of the EU climate and energy policy objectives entails a transition to a new energy system where Renewable Energy Sources (RES) are used and new technologies are developed and adopted. To some extent, this will require the **decentralization of the energy system** and **evolution in the roles of energy producers and consumers**, so that new opportunities to generate renewable energy and deploy new technologies are realized[3]. Several governments have set ambitious targets and have started to implement support schemes aimed at facilitating market implementation. The degree to which these policies have been successfully implemented varies between countries, but **geothermal energy** penetration into the energy market is very limited compared to its potential to decarbonize Europe[4].

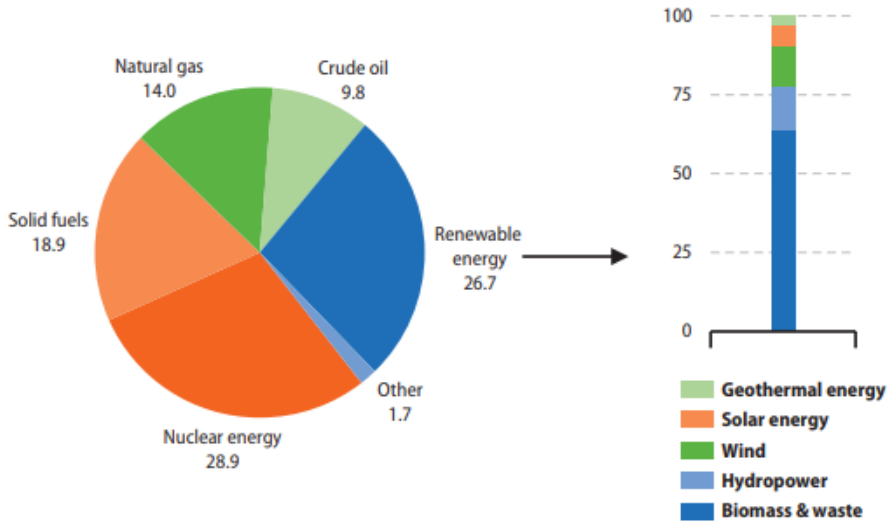

Figure 1: *Production of primary energy in EU28 in 2015 (% of total, tonnes of oil equivalent) (Source: Eurostat, 2017)* [4].

With the increasing global energy consumption, geothermal energy usage is set to increase in the future. However, the geothermal sector remains small at the European level and quite fragmented, being more dynamic in some states, less so in others. The availability of the resource in a given country's geology plays a role, but so does the existence of a suitable regulatory framework, sufficient political and public support, and, not least the available financial instruments. There are some classical economic support instruments available for renewable energy and geothermal

[1] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (2018)
[2] National Energy and Climate Plans (NECPs) (2019)
[3] Models of Local Energy Ownership and the Role of Local Energy Communities in Energy Transition in Europe (2018)
[4] Eurostat Key figures on Europe (2017)

projects in Europe providing support in different project phases (direct investment subsidies, bank loans, tax incentives, off-take support schemes for green heat, Indirect support schemes, etc.). However, **geothermal energy has been less attractive to alternative finance** than other types of renewables due to the risks and challenges that geothermal projects face also on the conventional financial markets.

Public perception influences geothermal projects either directly, in the form of local action groups, or indirectly, by defining the political climate for geothermal energy production. Several examples in different countries have shown that public opposition can considerably delay, or even stop, the deployment of geothermal projects[5]. On the other hand, people willing to invest in a community-based project can be drivers of renewable energy projects' development[3]. Building up the public perception and acceptance of RES, and geothermal energy in particular, is more and more important to speed up their development. This is essential also because energy is one of the most important factors for economic development and the competitiveness of the European economy. **Public acceptance** and **stakeholder management** are becoming increasingly important issues for successful geothermal development. However, fair engagement procedures may help to build and sustain **society's trust** in geothermal projects and their owners both on local and national levels[6].

In the past years, alternative finance and specifically community finance mechanism, such as crowdfunding within a local community became very successful in attracting large amounts of risk capital and loans in all types of projects. Within the renewable energy industry, very successful projects with solar energy and wind energy showed the potential of attracting local investors looking not only for a financial return but also for impact.

Geothermal developments may result in both positive and negative environmental and socio-economic impacts. In this aspect, sustainability assessment tools are useful to decision-makers and the general public in showing the progress of energy developments towards sustainability. Due to the unique characteristics of geothermal energy projects, specialized assessment tools are required to ensure that geothermal projects will be properly guided into following best practices and result in positive impacts in all sustainability dimensions: environmental, social and economic.

CROWDTHERMAL is focused on studying the necessary conditions for the development of community-based financing geothermal projects. For that reason, a **customized framework for assessing** all involved actor's **perception of the process**, **concerns and needs**, **public acceptance** and **participation issues,** is required.

The Case Study assessment protocol will be used to analyze 3 different Case Studies of community-funded or community-involving projects. Generally public acceptance is highly important to develop energy projects, however public acceptance and involvement is necessary to boost projects financially supported by the community itself. This innovative protocol will help to in-deep analyze the conditions surrounding successful geothermal projects involving the local community.

[5] Study on public perception of geothermal energy (D6.1) (2013)
[6] Engaging the Public on Geothermal Energy (2015)

3 OBJECTIVES OF THE CASE STUDY ASSESSMENT PROTOCOL

The CROWDTHERMAL Case Study Assessment Protocol will deliver a public perception assessment framework for the three case studies in CROWDTHERMAL. It will enable the generation of an **acceptance profile** for each case study through the assessment of project performance and public perception about important topics (risk, environmental, social, institutional and economic indicators). The protocol will be used to tackle different social awareness "resolution levels", including the perception of alternative finance, by investigating case studies that cover different types of resources, scales of application, project maturity, risk and community engagement, between others. The protocol will contribute to understand the requirements for social licensing to develop a Social License to Operate (SLO) model for the different geothermal technologies and installations. The results of the protocol will be further analyzed and will support the development of WP1-WP3 concepts, feeding the work that will be developed in WP4.

4 METHODOLOGY

While considering public perception and acceptance of renewable energy sources and geothermal energy, one shall take into account several decisive factors of various nature including social, economic, environmental, technological and scientific ones.

To obtain a complete and tailor-made protocol, this Case Study protocol has been designed in synergy with WP1, WP2, and WP3, integrating public awareness/perception, risks mitigation and financial aspects. Specifically, in Task 1.3 a brief sheet was prepared to gather general aspects of the project as people and entities involved in the project or the timeline of events. This task is focused on identifying and investigate the stakeholders' group involved in the case study, as well as their needs and visions, relevant networks and communication circles with details on financing, socio- and environmental psychological barriers and constraints, their risk evaluation and related factors.

Also, a questionnaire for collecting information on the risks of the case studies has been prepared in Task 3.1. This questionnaire includes a brief description of the case study and covers subjects as risk owners, types of risks and mitigation ways. The task consists of a demand analysis identifying the most important issues currently not fully mitigated by existing schemes.

Thus, this Case Study protocol will feed in the mentioned tasks, to integrate the results obtained and complete the information with aspects not mentioned but considered relevant for the development of the project. The protocol will be composed of several stages, enabling both the **characterization** and the **assessment of the perception** of the project by the involved public in each case study.

One first stage will consist of the general characterization of the project. It will include geographical, technical, socioeconomic (including finance) and environmental aspects. The second and third stages will consist of two different surveys, which will tackle public awareness (knowledge) and perception of geothermal projects. They will be separately carried out involving the case study stakeholders and experts (Advisory Committee).

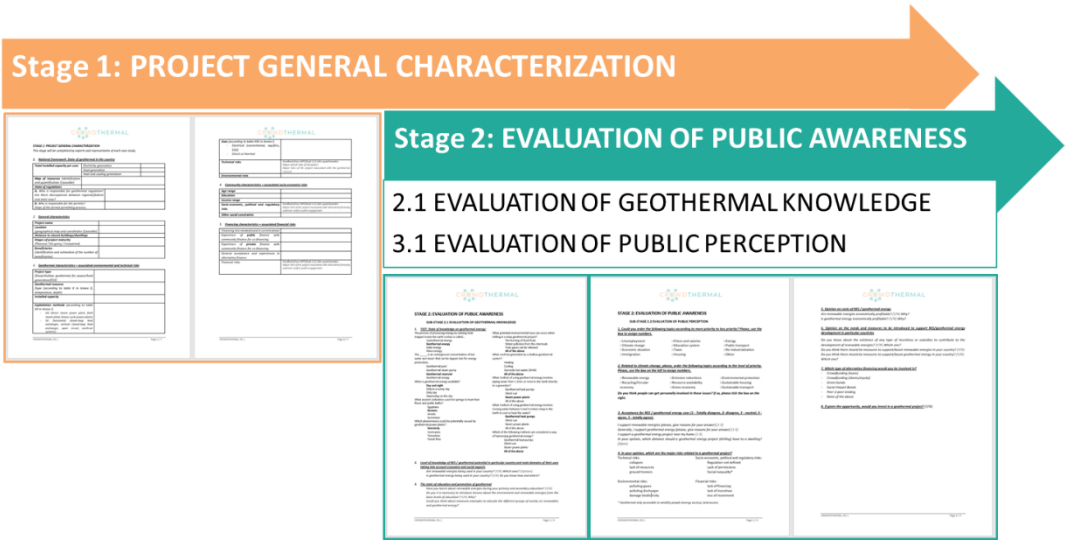

Figure 2: Scheme of CROWDTHERMAL Case Study assessment protocol

4.1. STAGE 1: PROJECT GENERAL CHARACTERIZATION

Prior to the design of a protocol to evaluate the public perception of different aspects of the process, a general characterization of the project is necessary to set up the most suitable indicators for each project. Not all case studies will be subject to the same conditions and risks, but the protocol needs to adapt to the different types of geothermal projects.

This stage will consist of the general characterization of the geothermal project, including external (framework) and internal characteristics and risks of the project. The stage includes the description of the national framework, general characteristics, geothermal characteristics and associated environmental and technical risks, community characteristics and associated socio-economic risks, financing characteristics and associated financial risks. As UNFC-2009[7], this stage is designed based on fundamental criteria as economy and society, field project status and geological knowledge, to be adaptable to characterize different types of geothermal projects. This stage will be carried out by experts and representatives of each case study.

Once the protocol is completed and the case studies are analyzed on its basis, some of the fields included in this first stage will be covered by the work done in Task 1.3 (general aspects and timeline for the projects) and in Task 3.1 (risk identification and assessment).

4.2. STAGE 2: EVALUATION OF PUBLIC AWARENESS

The education and promotion addressing decisive groups (decision-makers and administration of various levels) is an indispensable element of building public acceptance for these energy sources. Observations and experience of the experts show that the relevant knowledge is sometimes weak or superficial, which results, among others, in the unsatisfactory level of some documents and regulations, quality of social dialogue, the efficiency of cooperation with professionals and NGOs[8]. Previous researchers have identified some basic indicators of public perception of geothermal energy useful to obtain a picture to evaluate public performance in relation to geothermal projects[5]:

- State of knowledge on RES / geothermal energy,
- Orientation on basic national and EU-documents, strategies and obligations related to RES (geothermal energy),
- Level of knowledge of RES / geothermal potential in particular country and main domains of their uses taking into account economic and social aspects,
- Acceptance for RES / geothermal energy uses,
- Opinion on costs of RES / geothermal energy,

[7] United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources (2009)
[8] Public Perception of Geothermal Energy in Selected European Countries (2015)

- Opinion on the needs and measures to be introduced to support RES/geothermal energy development in particular countries,
- State of education and promotion addressing various groups of society,
- Proposals of concrete methods and tools of education on RES/geothermal energy dedicated to various groups of society.

Stage 2 will be composed of 2 sub-stages which will tackle the mentioned issues through surveys focused on the evaluation of the geothermal knowledge and the public perception of geothermal. The chosen indicators in this stage are based on those proposed by Kępińska and Kasztelewicz in their evaluation of the Public Perception of Geothermal Energy in Selected European Countries (2015).

4.2.1. EVALUATION OF GEOTHERMAL KNOWLEDGE

This first sub-stage 2.1 will evaluate the knowledge and general opinion about some topics related to renewable and geothermal energies, with the aim of identifying the gaps in education/communication that slows down the development of geothermal projects in the different countries. It will be conducted through an online survey; which questions will be based on the mentioned indicators. The survey will be filled up by two target audiences, two of them directly related to the geothermal Case Studies (investors and final consumers) and another one encompassing the external and non-project-related actors. In most cases, investors and the final consumer will be the same figure. Furthermore, to classify the results, information like country, range age and gender of the interviews will be collected (table 1). The survey will allow selecting different answers, with the aim of preparing statistics for the comparison of results.

Target audiences:		Respondent information (for classification):
END USERS	NOT END USERS	
<u>Spain:</u> **1. Investors=End users** <u>Iceland:</u> **1. Investors=End users** <u>Hungary:</u> **1. General public (end users)**	<u>Spain:</u> 1. **General public (regional division (tbd)** 2. <u>Iceland:</u> **1. General public (regional division)** <u>Hungary:</u> **1. General public (city division)**	**Country** **Age (range)** **Gender**

Table 1: Target audiences and respondent information collected for sub-stage 2.1.

The survey for the evaluation of public geothermal knowledge will include the following topics:

1. TEST: State of knowledge on geothermal energy
2. Level of knowledge of RES / geothermal potential in particular country and main domains of their uses taking into account economic and social aspects
3. The state of education and promotion of geothermal

4.2.2. EVALUATION OF PUBLIC PERCEPTION

This stage will consist of the evaluation of the public perception of geothermal and the identified risks. A new survey has been prepared to evaluate the perception of the groups on the risks associated with the project. The survey will also be answered by an external expert group (Advisory Committee). The resulting responses obtained from the non-experts' groups will be compared to those obtained from the Advisory Committee with the aim of identifying the gaps between the subjective and objective perceptions to develop tools able to tackle those differences and narrow those gaps.

Again, the survey will be filled up by two target audiences, two of them directly related to the geothermal Case Studies (investors and final consumers) and another one encompassing the external and non-project-related actors. This time, the external audience will also involve a group of experts (**Advisory Board/Experts Committee**). To classify the results, information like country, range age and gender of the interviews will be collected (table 2). The survey will allow selecting different answers, with the aim of preparing statistics for the comparison of results.

Target audiences:		Survey information (for classification):
Internal stakeholders **Investors** **Final consumers**	External audience **General/ Surrounding public** **Advisory Board/Experts Committee**	**Country** **Age** **Gender**

Table 2: Target audiences and respondent information collected for sub-stage 2.2.

The survey for the evaluation of the public perception of geothermal will include the following topics:

- Energy and climate change in the hierarchy of priorities
- Acceptance for RES / geothermal energy uses
- Opinion on costs of RES / geothermal energy
- Opinion on the needs and measures to be introduced to support RES/geothermal energy development
- State of knowledge of incentives or subsidies to contribute to the development of renewable energies
- Involvement in alternative financing
- Opinion on risks related to a geothermal project

5 CASE STUDY ASSESSMENT PROTOCOL

STAGE 1: PROJECT GENERAL CHARACTERIZATION

This stage will be completed by experts and representatives of each case study.

1. ***National framework: State of geothermal in the country***

Total installed capacity per uses	*Electricity generation*	
	Heat generation	
	Heat and cooling generation	
Map of resources *(identification and quantification if possible)*		
State of regulations		
A. *Who is responsible for geothermal regulation? Are there discrepancies between regional/federal and state laws?*		
B. *Who is responsible for the permits? Steps of the formal permitting process.*		

2. ***General characteristics***

Project name	
Location *(geographical map and coordinates if possible)*	
Distance to closest buildings/dwellings	
Stages of project maturity *(Planned / On-going / Completed)*	
Beneficiaries *(identification and estimation of the number of beneficiaries)*	

3. ***Geothermal characteristics + associated environmental and technical risks***

Project type *(Deep/shallow geothermal for power/heat generation/EGS)*	
Geothermal resource *(type (according to table 1 in Annex I), temperature, depth)*	
Installed capacity	

Exploitation methods *(according to table 2 in Annex I)* - *DG (Deep Geothermal) (direct steam power plant, flash steam plant, binary cycle power plants)* - *SG (Shallow Geothermal) (horizontal closed-loop heat exchanger, vertical closed-loop heat exchanger, open circuit, earth-air systems)*	
Uses *(according to table 3 in Annex I)* - *Electrical (conventional, aquifers, EGS)* - *Direct or thermal*	
Technical risks	***Feedback from WP3 (task 3.1) risks questionnaire:*** *Major overall risks of the project* *Major risks of the project associated with the geothermal resource*
Environmental risks	

4. ***Community characteristics + associated socio-economic risks***

Age range	
Education	
Income range	
Socio-economic, political and regulatory risks	***Feedback from WP3 (task 3.1) risks questionnaire:*** *Major risks of the project associated with alternative financing solutions and/or public engagement*
Other social constraints	

5. ***Financing characteristics + associated financial risks***

Financing mix needed/used in current phase	
*Experience of **public** finance with community finance for co-financing*	
*Experience of **private** finance with community finance for co-financing*	
General acceptance and experiences in alternative finance	
Available guarantees/tax incentives to be used for renewable energy (or specific geothermal energy projects)	
Financial risks	***Feedback from WP3 (task 3.1) risks questionnaire:*** *Major risks of the project associated with alternative financing solutions and/or public engagement*

STAGE 2: EVALUATION OF PUBLIC AWARENESS

SUB-STAGE 2.1 EVALUATION OF GEOTHERMAL KNOWLEDGE

1. ***TEST: State of knowledge on geothermal energy***

The process of producing energy by utilizing heat trapped inside the earth's surface is called…

- ☐ Harnessing hydrothermal energy
- ☐ **Harnessing geothermal energy**
- ☐ Harnessing solar energy
- ☐ Harnessing wave energy

The _____ is an underground concentration of hot water and/or steam that can be tapped into for energy production**.**

- ☐ Geothermal pool
- ☐ Geothermal steam pump
- ☐ **Geothermal reservoir**
- ☐ Geothermal energy

When is geothermal energy available?

- ☐ **Day and night**
- ☐ Only on a sunny day
- ☐ Only day
- ☐ Depending on the day

What ancient civilization used hot springs to heat their floors and public baths?

- ☐ Egyptians
- ☐ **Romans**
- ☐ Greeks
- ☐ Sumerians

Which phenomenon could be potentially caused by geothermal power plants?

- ☐ **Seismicity**
- ☐ Hurricanes
- ☐ Tornadoes
- ☐ Forest fires

What could be generated by a shallow geothermal system?

- ☐ Heating
- ☐ Cooling
- ☐ Domestic hot water (DHW)
- ☐ **All of the above**

What method of using geothermal energy involves piping steam from 1.6 km or more in the Earth directly to a generator?

- ☐ Geothermal heat pumps
- ☐ Direct use
- ☐ **Steam power plants**
- ☐ All of the above

What method of using geothermal energy involves moving water between 3 and 6 meters deep in the Earth to cool or heat the water?

- ☐ **Geothermal heat pumps**
- ☐ Direct use
- ☐ Steam power plants
- ☐ All of the above

Which of the following methods are considered a way of harnessing geothermal energy?

- ☐ Geothermal heat pumps
- ☐ Direct use
- ☐ Steam power plants
- ☐ **All of the above**

2. ***Level of knowledge of RES / geothermal potential in particular country and main domains of their uses taking into account economic and social aspects***

	Yes	No
Are renewable energies being used in your country? Which ones?	☐	☐
Is geothermal energy being used in your country? Do you know how and where?	☐	☐

3. ***The state of education on renewable energy and promotion of geothermal***

	Yes	No
Have you learnt about renewable energies during your primary and secondary education?	☐	☐
Do you it is necessary to introduce lessons about the environment and renewable energies from the basic levels of education? Why?	☐	☐
Which measures would encourage you to support renewable/geothermal projects?		

SUB-STAGE 2.2 EVALUATION OF PUBLIC PERCEPTION

1. Could you order the following topics according to more priority (1) to less priority (5)? Please, use the box to assign numbers

□ Economic situation: prices and salaries, taxes, re-industrialization
□ Social issues: unemployment, education system, housing, immigration
□ Environment: climate change, pollution, energy, recycling
□ Public health: research, education, safety issues
□ Public transport and infrastructures

2. Acceptance for RES / geothermal energy uses

	Totally disagree	Disagree	Neutral	Agree	Totally agree
All in all, I support renewable energies (please, give reasons for your answer)	☐	☐	☐	☐	☐
Generally, I support geothermal energy (please, give reasons for your answer)	☐	☐	☐	☐	☐
I would support a geothermal energy project near my home	☐	☐	☐	☐	☐

3. I perceive geothermal energy as…

	Totally disagree	Disagree	Neutral	Agree	Totally agree
Meaningful	☐	☐	☐	☐	☐
Expensive	☐	☐	☐	☐	☐
Transparent	☐	☐	☐	☐	☐
Technologically mature	☐	☐	☐	☐	☐
Simple	☐	☐	☐	☐	☐
Well planned	☐	☐	☐	☐	☐
Risk-free	☐	☐	☐	☐	☐
Environment-friendly	☐	☐	☐	☐	☐
Comprehensible	☐	☐	☐	☐	☐
Necessary for the energy transition	☐	☐	☐	☐	☐
Democratic	☐	☐	☐	☐	☐
Conducive to jobs	☐	☐	☐	☐	☐
Future-oriented	☐	☐	☐	☐	☐

4. In your opinion, which are the major risks related to a geothermal project?

Technical risks: □ Collapses □ Lack of resources □ Ground tremors	Socio-economic, political and regulatory risks: □ Regulation not defined □ Lack of permissions □ Social inequality[9]
Environmental risks: □ Polluting gases □ Polluting discharges □ Damage biodiversity	Financial risks: □ Lack of financing □ Lack of incentives □ Loss of investment

5. Opinion on costs of RES / geothermal energy

	Totally disagree	Disagree	Neutral	Agree	Totally agree
I perceive renewable energies as economically profitable	☐	☐	☐	☐	☐
*I perceive **geothermal** energy economically profitable*	☐	☐	☐	☐	☐

6. Opinion on the needs and measures to be introduced to support RES/geothermal energy development in particular countries

	Yes	No
Do you know about the existence of any type of incentives or subsidies to contribute to the development of renewable energies? Which one?	☐	☐
I think there should be measures to support/boost renewable energies in your country	☐	☐
*I think there should be measures to support/boost **geothermal** energy in your country. Which one?*	☐	☐

7.** Several renewable energy initiatives are becoming energy companies themselves and selling energy to customers and businesses. This way the local community (for example if they are an investor/co-owner) can get a lower energy price.* ***If given the opportunity, would you invest in a geothermal project?

	Totally disagree	Disagree	Neutral	Agree	Totally agree
If given the opportunity, I would invest in a geothermal project	☐	☐	☐	☐	☐

[9] Geothermal only accessible to wealthy people (energy access), land access.

8. Which type of alternative financing you would prefer to be involved in?

		Strong preference	Preference	Neutral	Low preference	No preference
Crowdfunding	***Crowdfunding (shares/equity):*** *Financing model where a business raises funds directly without going through a bank in return for equity/shares in that business*	☐	☐	☐	☐	☐
	Crowdfunding (loans) (also known as peer-2-peer lending): *Financing model where a business raises funds directly (without going through a bank) in return for a loan*	☐	☐	☐	☐	☐
	Crowdfunding (reward-based): *Financing model where a business raises funds directly without going through a bank in return for non-monetary rewards, like products*	☐	☐	☐	☐	☐
Direct lending	***Regular loans:*** *Loans provided by the financial institution itself, funding is gathered by the financial institution.*	☐	☐	☐	☐	☐
	Green bonds: *Fixed-income instrument that is specifically earmarked to raise money for climate and environmental projects.*	☐	☐	☐	☐	☐
	Social Impact Bonds: *Pay for success financing instruments for projects that will create better social outcomes whereby the payment to investors is flexible, based on the achieved savings.*	☐	☐	☐	☐	☐
Leasing	***Operational lease:*** *An institution provides the funding for a project to parties who are developing the project. The parties pay it back in periodic installments. At the end of the project, the facilities are owned by the institution.*	☐	☐	☐	☐	☐
	Financial Lease: *A leasing company pays for assets and/or production of a project for parties who are developing the project. The parties pay it back in periodic installments. At the end of the project, the facilities can be bought often at a price agreed in advance.*	☐	☐	☐	☐	☐

9. *A* ***cooperative*** *is an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned enterprise.* ***Would you be involved in a cooperative to benefit of any of the alternative financing models mentioned above?***

	Totally disagree	Disagree	Neutral	Agree	Totally agree
If given the opportunity, I would be involved in a cooperative to benefit from any of alternative financing models	☐	☐	☐	☐	☐

10. Open lines for any other remarks, questions, hints

_____

_____

ANNEX I

<table>
<tr><th colspan="3">RESOURCES</th><th colspan="2">USES</th><th colspan="4">EXPLOITATION TECHNOLOGIES</th></tr>
<tr><td rowspan="2">HIGH ENTHALPY resources (>150°C) suitable for electrical generation with conventional cycles</td><td>High-Temperature Geothermal Resources</td><td>Temperatures above 150ºC</td><td>Thermo-Electrical Production: Geothermal power plants use steam produced from earth's heat to generate electricity and/or heat

Power plant type depends on reservoir's temperature, pressure, and fluid content
High-temperature geothermal deposits can be used to produce heat and/or electricity from:
Conventional geothermal reservoirs
Hot aquifers associated with deep sedimentary basins (known as HSA - Hot Sedimentary Aquifer)
Enhanced geothermal system (EGS)</td><td>Power generation (100% dispatchability and base load)

Heat

CHP → Combined heat and power</td><td rowspan="2">DEEP geothermal systems (500-5000m)</td><td>Petrothermal System ('hot dry rock' process):</td><td>Injection of water into the subsoil under high pressure to increase the permeability of the hot and dry rock for water circulation by hydraulic fracturing (Enhanced Geothermal System → EGS)</td><td rowspan="2">Depending on the characteristics of the geothermal fluid available → 3 types of geothermal plants for electricity generation

1. DIRECT STEAM POWER PLANT
2. FLASH STEAM PLANT
3. BINARY CYCLE POWER PLANTS (can operate with geothermal fluid temperatures ranging from 85°C to 170°C)</td></tr>
<tr><td>Hydrothermal System:</td><td>Existing aquifers are used to pump hot water (>100°C for electricity generation)</td></tr>
<tr><td rowspan="3">LOW ENTHALPY resources (<150°C)* for direct heat uses (and electricity generation by using binary cycles)</td><td>Medium-Temperature Geothermal Resources</td><td>Temperature ranging from 100º to 150ºC</td><td rowspan="2">Direct (or thermal) use: A well is drilled into a geothermal reservoir to provide a steady stream of hot water. A mechanical system (piping and pumps, heat exchanger. control system) delivers heat directly for the intended use</td><td rowspan="2">Heating and cooling for buildings and district heating networks (which can be backed by cogeneration systems, biomass boilers, etc.)
Agricultural use: Greenhouses, drying of agricultural products, etc.
Aquaculture: Fish farms, algae production
Industrial process
Balneotherapy: Spas and others</td><td rowspan="3">SHALLOW geothermal systems (<500m)</td><td colspan="2" rowspan="3">Depending on the temperature of the geothermal resource, can be exploited directly or using a GeoExchange system (GHP + loop heat exchanger)

Geothermal loop systems, use of groundwater heat, energy piles and geostructures. It penetrates no more than 500 meters into the subsoil and use layers with temperatures 8-20°C. Several technologies have been developed to leverage heat from the subsurface based on the accessibility to the geothermal resource. All of them could classified into two main types:
Open circuits, where water is pumped from an aquifer
Closed circuits, where an exchanger is installed on-site to exploit the energy resources</td><td rowspan="3">1. HORIZONTAL CLOSED-LOOP HEAT EXCHANGER

2. VERTICAL CLOSED-LOOP HEAT EXCHANGER

3. OPEN CIRCUIT

4. EARTH-AIR SYSTEMS</td></tr>
<tr><td>Low-Temperature Geothermal Resources</td><td>Temperature ranging from 30º to 100ºC</td></tr>
<tr><td>Very Low-Temperature Geothermal Resources</td><td>Energy stored in the Earth or in groundwater at temperatures below 30ºC</td><td>Geothermal Heat Pumps (GHPs) also known as GeoExchange: Use the constant temperatures near the surface of the earth to heat and cool. GHPs transfer heat from the ground (or water) into buildings during the winter and reverse the process in the summer.</td></tr>
</table>

Table 1: Geothermal resources, uses and exploitation technologies classification. *Authors: Margarita de Gregorio (GEOPLAT), Paloma Pérez (GEOPLAT)*

	Development Phases	Technical levels	Financial levels	Social levels
1	**Project definition**	- Economic (e.g. FIT) and legal (e.g. mining law) framework - Data mining - Evaluation of existing geoscientific data - Area of interest identification - Securing exploration license	Type of capital: **Risk-absorbing, risk-sharing** Financial risk: **High** Capital required: **Low**	**Formal Participation (legally binding):** Information of responsible authorities **Informal participation:** Announcement of the project, asking for need of information/communication, offering financial participation opportunities **Communication (permanent task):** Identification of opportunities and risks, far-reaching transparency, accessibility of information materials
2	**Exploration**	- Acquiring of new geoscientific data, like 3D seismic survey - Evaluation of newly acquired data - Integration with existing datasets - Identification of potential geothermal targets (e.g. structures, faults, aquifers) - Drill site identification - Well path planning - Securing drilling and testing permits	Type of capital: **Risk-absorbing, risk-sharing** Financial risk: **High** Capital required: **Medium**	**Formal Participation (legally binding):** Information of responsible authorities, public involvement for planning permits **Informal participation:** Announcement of the project, asking for need of information/communication, offering financial participation opportunities **Communication (permanent task):** Description of the process, different phases, what is happening, direct communication with relevant stakeholder groups
3	**Drilling**	**A. 1st well** - Drill pad construction - Drilling and completion of the first well - Logging, testing (production and injection test) and sampling - If applicable: well and/or reservoir enhancement **B. Resource development** - Drilling and completion of subsequent well(s) - Logging, testing, sampling and if applicable: enhancement - Circulation test - Securing construction permits	Type of capital: **Risk-sharing** Financial risk: **High** Capital required: **High** Type of capital: **Debt** Financial risk: **Medium to high** Capital required: **High**	**Formal Participation (legally binding):** Public involvement for drilling permits (information, hearing of the stakeholders, public according to legal framework documentation) **Informal participation:** Regional information markets, topical tables (risks, financing, environmental impacts), dialogue groups **Communication (permanent task):** Local office with sufficient consultation times, site visits of existing projects/video
4	**Construction**	- Construction of the plant (power/heating) - If applicable: construction or extension of district heating network - Connection to the grid or district heating network - Securing operation permits	Type of capital: **Debt** Financial risk: **Low** Capital required: **High**	**Formal Participation (legally binding):** Public involvement for construction permits (information, hearing of the stakeholders, public according to legal framework documentation) **Informal participation:** Regional information markets, topical tables (risks, financing, environmental impacts), dialogue groups **Communication (permanent task):** Public construction diary
5	**Operation**	- Power and/or heat production - Maintenance - Monitoring	Type of capital: **Debt** Financial risk: **Low** Capital required: **Medium**	**Formal Participation (legally binding):** Monitoring-information to the stakeholders, public according to legal framework **Informal participation:** Offering further financial participation opportunities, spin off to other joint energy projects (RES, efficiency) **Communication (permanent task):** Operation starting party; "local energy festival" on a yearly base, operation diary; website showing produced energy, saved CO_2-emissions
6	**Decommissioning and post-closure**	- Plug and abandon of wells - Decommissioning of the plant - Monitoring of the abandoned wells	Type of capital: **Reserves, risk-absorbing (Government)** Financial risk: **Medium** Capital required: **Low**	**Formal Participation (legally binding):** Decommissioning-information to the stakeholders, public according to legal framework (focus environment, risk, post-utilisation)

Table 2: Geothermal project phases classification