Geothermal
ERA-NET

Actions to bridge gaps, overcome barriers and promote the use of geothermal energy in Europe

November, 2014

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NL Agency

November, 2014

Publisher:

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Website: http://www.geothermaleranet.is/

ISBN: 978-9979-68-360-5

The Geothermal ERA NET is supported by the European Union's Seventh programme for research, technological development and demonstration under grant agreement No 291866

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Abstract

This report brings together the results of the work in Work package 2 of the Geothermal ERANET, and comes to a set of recommendations on how to bridge gaps, overcome barriers and promote the use of geothermal energy in Europe. The consortium has identified nine themes or clusters for joint work, which all have relevance for promoting the use of geothermal energy in Europe.

The report presents an overview of ongoing international work that should be complemented with Geothermal ERANET joint actions. The report concludes with suggestions for joint activities on: operational issues, a European Geothermal Information Platform, new concepts, and risk mitigation. The actual definition and selection process will be taken up in Work package 4 of the Geothermal ERANET.

Executive summary

A key activity within Work package 2 of the Geothermal ERANET is to bring together the results of the major work in the Work package, and come to a set of recommendations to bridge gaps, overcome barriers and promote the use of geothermal energy in Europe. Based on these results, Work package 4 will start its work on development of joint activities.

This report brings together the common ground in Barriers and Opportunities, and RD&D issues, and combines this with the knowledge of the status and policies of geothermal energy and ongoing RD&D projects in the countries participating in the Geothermal ERANET.

Having brought all this together, we present nine themes that should be considered for joint actions of the Geothermal ERANET:

1. Regulations
2. Economics & Risk-mitigation
3. New/innovative concepts & Applications
4. Operation
5. Subsurface/reservoir knowledge
6. Structuring the geothermal sector
7. Public & Education
8. Anthropogenic influence
9. Drilling

All of these actions have relevance for the promotion of the application of geothermal energy. Although work on all of them is recommended, we advise to make a realistic and pragmatic selection for our first joint activities, within the scope of work package 4.

To facilitate the development of joint activities, this report also offers a brief overview of recent or ongoing European and international activities. This overview forms a basis to identify the Joint activities that would best complement existing work.

The report presents suggestions for joint actions, which need to be further elaborated within Work package 4 of the Geothermal ERANET, and ways to organise them.

1. Introduction

A key activity within Work package 2 of the Geothermal ERANET is to bring together the results of the major work and to deliver a set of recommendations to bridge gaps, overcome barriers and promote the use of geothermal energy in Europe. Based on these results, Work package 4 shall start its work on the development of joint activities.

The general objective of the ERA-NET scheme under FP7 is to develop and strengthen the coordination of national and regional research programmes. ERANET actions provide a framework for actors implementing public research programmes to coordinate their activities e.g. by developing joint activities or by mutually supporting joint calls for trans-national proposals.

The Geothermal ERANET has stated in its project proposal that it intends to be an enabler for the integration of national research and development agendas into a coherent European geothermal R&D programme. A significant target will be to complement the EERA Joint Programme on Geothermal Energy. This report contributes to this target.

Specific objectives relevant to WP2 are as follows:

- Recommend measures to strengthen European geothermal development in order to meet short-term targets according to National Renewable Energy Action Plans and future contributions to renewable energy supply;
- Foster synergies at regional and pan-European level by mobilizing competitive and non-competitive funds for research in a more coordinated way through joint activities;
- Achieve a critical mass to address cross-thematic research targets, thus enhancing cooperation and avoiding fragmentation.

Within Work package 2, the following four reports provide the building blocks that serve as a basis for the recommendations in this report. These reports are available from the website at www.geothermaleranet.is:

- D2.1 Geothermal energy status and policy review
- D2.2 Inventory of RD&D project highlights
- D2.3 Technical and non-technical barriers & opportunities – ERANET Geothermal energy
- D2.4 RD&D Needs – ERANET Geothermal energy

This report focuses on three questions:

- What is the common ground for collaboration in the participating countries, when looking at both RD&D needs as well as barriers and opportunities for geothermal energy there? (Chapter 2);
- What kind of collaborations can be envisaged (Chapter 3);
- How do these priorities complement ongoing international actions (Chapter 4).

On the basis of these Chapters, the concluding Chapter will put forward our recommendations.

2. Common issues in Geothermal ERANET countries

The geothermal ERANET has made an inventory of barriers and opportunities for increased utilisation of geothermal energy, and an inventory of RD&D Needs. The results have been analysed and grouped thematically, with a view to facilitate the search for common ground for collaboration. This has been done separately for barriers and opportunities on the one hand, and RD&D needs on the other hand (see the reports D2.3 and D2.4 on www.geothermaleranet.is)

Seven thematic clusters were identified for barriers and opportunities, and six thematic clusters for RD&D needs. The table below shows these clusters. It also shows that barriers and opportunities for a specific theme often, but not always give rise to RD&D needs. As an example, progress on regulations is primarily an issue for policy makers.

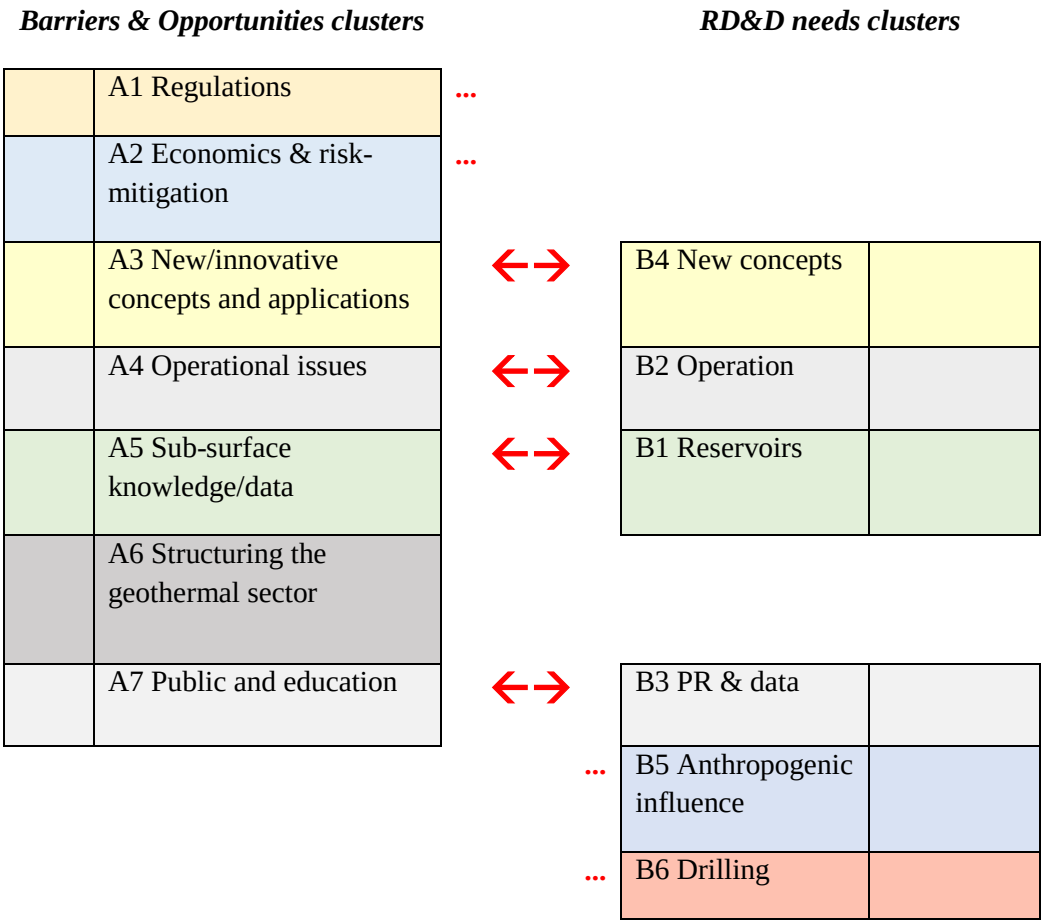

Figure 1 Links between clusters in barriers and opportunities, and themes in RD&D needs for forwarding geothermal energy

Linking the clusters of barriers and opportunities and RD&D needs shows clear overlaps, reducing the total number of clusters to nine.

1. Regulations (A1)
2. Economics & Risk-mitigation (A2)
3. New/innovative concepts & applications (A3/B4)
4. Operation (A4/B2)
5. Subsurface/reservoir knowledge (A5/B1)
6. Structuring the geothermal sector (A6)
7. Public & Education (A7/B3)
8. Anthropogenic Influence (B5)
9. Drilling (B6)

A more detailed representation, including sub-clusters is presented in Figure 2.

Barriers & Opportunities clusters			***RD&D needs clusters***	
	A1 Regulations	...		
a investment	A2 Economics & risk-mitigation	...		
b operational support				
c risk mitigation				
	A3 New/innovative concepts and applications	↔	B4 New concepts	A innovative concepts
				B heat
				C power cycle
	A4 Operational issues	↔	B2 Operation	A operational issues
				B injection issues
				C pumps & components

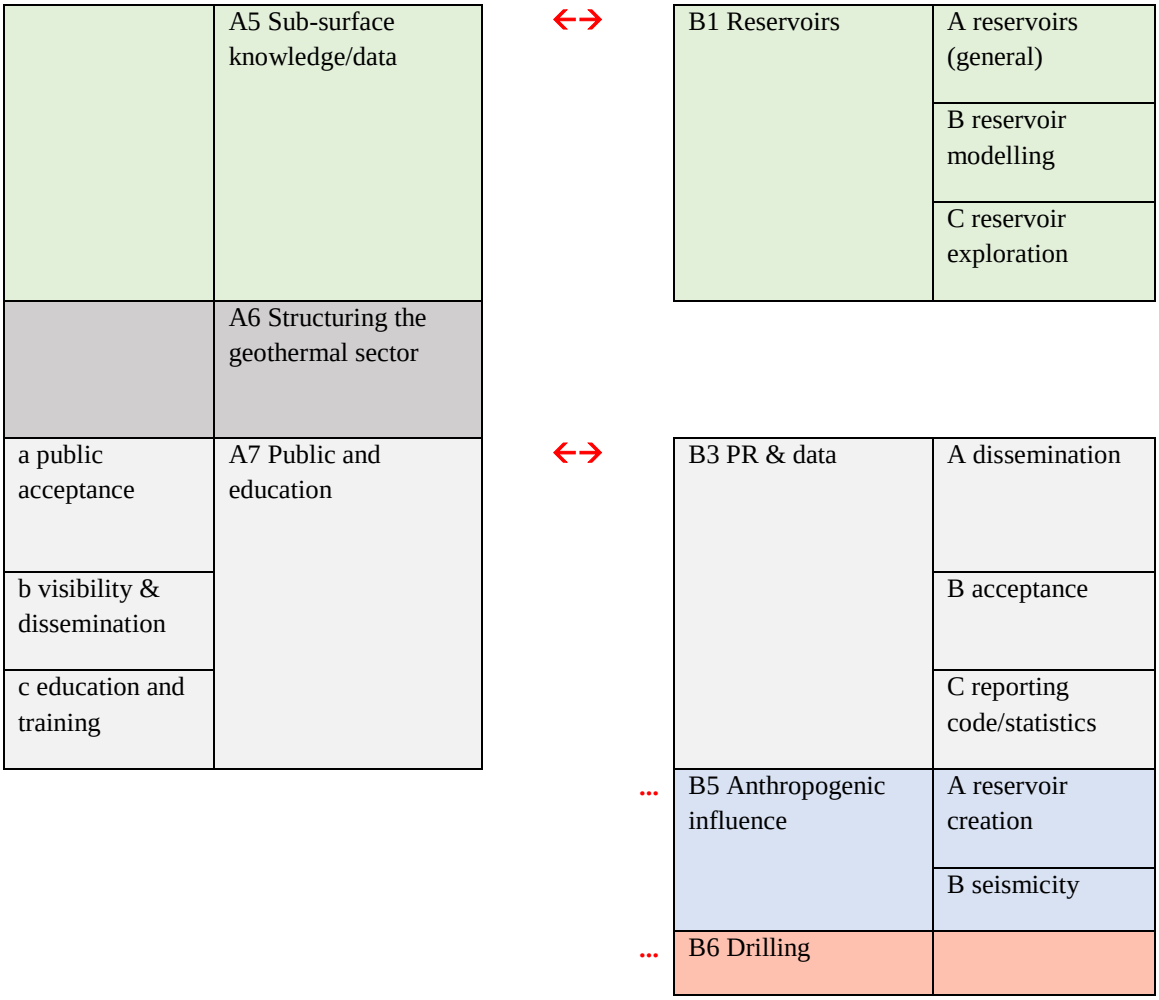

Figure 2 Clusters and sub clusters for collaboration

Addressing all of these clusters is important to increase the market penetration of geothermal energy in Europe.

3. Ongoing and recent international work

3.1 European geothermal research projects

Within the FP6 and FP7 work, and also within IEE, a number of projects on geothermal energy have been supported. The table below shows the most relevant European projects with their category/ies. These projects have been included here to facilitate considering the complementarity of our intended joint activities. Table 1 Recent Europe-(co)funded projects on geothermal energy. Clicking on titles leads you to the project website

Table 1 Recent Europe-(co)funded projects on geothermal energy

Short title & website link	Programme	Description	Regulations	Economics & risk mitigation	Innovative concepts/ applications	Operation	Subsurface/reservoir knowlegde	Structuring the geothermal sector	Public & Education	Anthropogenic influence	Drilling
GEOSTRAS	NER 300	Geothermal power project, awarded 2014, to produce both electricity (6,7 MWe) and heat (35 MWth) in the Alsace region			x					x	
Draskovec power	NER 300	Geothermal power project in Croatia, 3.1 MWe, combined with heat utilisation and spas			x						
EGS Hungary	NER 300	Geothermal power project, near Ferencszállás			x					x	
Soultz	FP7 FP6	Pilot plant EGS in Soultz-sous-Forets, in operation since 2008			x					x	
IMAGE	FP7	Integrated methods for advanced geothermal exploration					x				
GEISER	FP7	Investigate and mitigate induced seismicity								x	
LOW-BIN	FP6	Efficient low-temperature geothermal binary power – novel Rankine cycle units			x						
ENGINE	FP6	Coordination action, to support R&D for EGS systems			x						
I-GET	FP6	Integrated exploration technologies for deep fractured geothermal systems					x				
HITI	FP6	High temperature instruments for supercritical reservoir characterization					x				

Short title & website link	Programme	Description	Regulations	Economics & risk mitigation	Innovative concepts/ applications	Operation	Subsurface/reservoir knowlegde	Structuring the geothermal sector	Public & Education	Anthropogenic influence	Drilling
KECSKEMET	IEE	Assist city of Kecskemét in switching to geothermal district heating, including reinjection			x	x					
GEODH	IEE	Accelerate the uptake of geothermal district heating	x		x				x		
GEOELEC	IEE	Action plan for promoting geothermal electricity generation		x	x				x		
GEOFAR	IEE	Geothermal finance and awareness – including risk mitigation proposal		x					x		
GTR-H	IEE	Develop a framework for geothermal heat regulation/legislation	x						x		
GEOCOM	FP7	Geothermal Communities central/eastern Europe - cascading use of geothermal energy			x						

Table above shows for which topics a check of complementarity is necessary, before setting up a joint activity

3.2 International collaborations on geothermal energy

This section presents worldwide and European collaborations on geothermal energy, and introduces their nature and priorities. Consortia considering joint activities can use this section to guide their evaluation of other groups working on the same or similar subjects.

3.2.1 IEA Geothermal Implementing Agreement

The IEA Geothermal Implementing Agreement (IEA-GIA) brings together governments from 15 IEA member countries from all over the world, the European Commission, and a number of large companies working on geothermal. Efforts concentrate on encouraging, supporting and advancing the sustainable development and use of geothermal energy worldwide both for power generation and direct-heat applications.

The activities of the network are organised in Annexes (to the Implementing Agreement). More information from IEA-GIA can be retrieved from their website www.iea-iga.org. Table 2 below shows the current work programme

Table 2 Ongoing Annexes of IEA-GIA

Annex	Title	Participants Annex leader in Bold
I	Environmental impacts of geothermal development	AU, CH, IS, IT, JP, MX, **NZ**, US
III	Enhanced geothermal systems	AU, CH, CA, DE, EC, ES, FR, IT, JP, KR, NO, UK, **US** + industry
VII	Advanced geothermal drilling and logging technologies	AU, CA, EC, IS, MX, NZ, NO, **US**
VIII	Direct use of geothermal energy	CA, **CH,** FR, IS, JP, NZ, KR, UK, US
X	Data collection and information	**DE/CH** – all members
XI	Induced seismicity	AU, CH, DE, EC, FR, IS, JP, KR, NZ, **US**
XII	Deep roots of volcanic geothermal systems	CH, **IS,** NZ,

3.2.2 International Geothermal Association

The International Geothermal Association (IGA) is a non-governmental organisation with 5 200 members in 65 countries all around the world. Its aim is to encourage, facilitate and, when appropriate, promote the coordination of activities related to worldwide research, development and application of geothermal resources. IGA's scope includes shallow geothermal energy, to be used with heat pumps. IGA's headquarters are located in Bochum, Germany. It is the organiser of the World Geothermal Congress, and one of the founding fathers of the International Renewable Energy Alliance. More information on IGA can be found from http://www.geothermal-energy.org.

3.2.3 European Geothermal Energy Council

EGEC, the *European Geothermal Energy Council* is a non-profit organisation. It unites national geothermal association, industries and researchers working on geothermal energy. Its goal is to promote the use of geothermal energy, in particular through voicing the benefits of geothermal energy among European institutions. More information on EGEC can be found through http://egec.info. EGEC also initiates projects. A listing of EGEC projects is given in Table 3.

Table 3 Recent projects of EGEC

Acronym	Summary	Participants
GEOELEC	Action plan towards more geothermal electricity generation in Europe. Completed.	EGEC, BRGM, CRES, CNR-ICG, APPA, GGSC, EnBW, Mannvit, GFZ, TNO
GEODH	Targeted actions to support an increased role of direct use of geothermal energy	EGEC, MFGI, AGE, Bulgarian local authorities, SDDE, COSVIG, AFPG, Polish academy of sciences, Grønenergi, City of Heerlen
Repowermap	Interactive map, that allows uploading your own renewable energy project, including all renewable energy sources	See website
REGEOcities	Regulations on geothermal heat pumps	
Groundmed	GSHP for Mediterranean countries	

3.2.4 European Technology Platform on Renewable Heating and Cooling

The European Technology Platform on Renewable Heating and Cooling (ETP-RHC) brings together stakeholders from the biomass, geothermal and solar thermal sector - including the related industries - to define a common strategy for increasing the use of renewable energy technologies for heating and cooling. There are four technology panels, and the Geothermal Technology Panel is the most relevant for geothermal. It is managed by EGEC. Also important for geothermal is the Cross Cutting Technology Panel, in particular the group on district heating and cooling.

March 2014, the ETP RHC has published a Geothermal Technology Roadmap. This roadmap considers both shallow geothermal and 'deep' geothermal. Areas for proposed action are resources, drilling, production – including reservoir creation and operation -, and EGS. Moreover, ETP RHC has published "Strategic Research Priorities for Geothermal Technology" in April 2012. The priority areas are resource assessment, drilling, and surface installations/components. A listing of the research priorities is given as Appendix 2.

3.2.5 EERA JPGE

The European Energy Research Alliance (EERA) contributes to coordinate a massive public research effort to develop more efficient and cheaper low-carbon energy technologies and is a public research pillar of the EU Strategic Energy Technology Plan (SET-Plan). Its Joint Programme Geothermal Energy (EERA-JPGE) aims at accelerating the development and market uptake of key geothermal technologies for power production and co-production of heat and power. More information on EERA JPG can be found through

http://www.eera-set.eu/eera-joint-programmes-jps/15-eera-joint-programmes/geothermal/

4. Suggestions for joint activites

The objective of this report is to propose actions to bridge gaps, overcome barriers and promote the use of geothermal energy in Europe. The actual development and implementation of joint activities will be taken on in the Work packages 4 and 7 of the Geothermal ERANET. Within Work package 4, the participants will elaborate ideas for joint activities and decide whether or not to participate in a specific action. Within Work package 7, the activities will be implemented.

This report finalizes the work done in Work package 2. Based on frequently mentioned issues during discussions within the Geothermal ERANET, the authors of this report propose several activities that are worth considering. However, it is important to realise that in order for these activities to be implemented, countries need to allocate budgets. This issue will be addressed in Work package 4.

In the appendix to this report, we bring together the insights of the work done in Work package 2 theme-by-theme, on a very general level. These insights can be helpful when considering joint activities.

Suggested activities:

Names of countries indicate countries that have informally shown an interest to pursue such an activity. Formal participation is still open and to be decided

Operational issues
Best practices on operation of wells, avoiding corrosion, dealing with scaling and precipitation, keeping the pumps in good operating condition …
Information exchange and potentially joint studies (e.g. best practices)
NL, DE, …

European Geothermal Information Platform
Realise cross-border availability of geothermal information and data
Extension of the actual joint work of stage 1 of EGIP to other countries; Joint call for full implementation, refer to the publications of Work package 3 of Geothermal ERANET.
FR, IT, CH, HU, …

New concepts
E.g. combinations of geothermal energy and CO2 utilisation – but many other specific topics from new concepts could be selected.
In-depth information exchange on ongoing projects, potentially joint call to address particularly beneficial combinations
IS, NL, …

Risk mitigation
Inter-country learning on the set-up and management of public risk-mitigation schemes
In-depth information exchange
FR, NL, CH, …

5. Various ways of collaboration in Joint Activities

There are various possible ways for international collaboration to foster utilization of geothermal energy and innovation in Europe, which may in principle range from information exchange to multinational financing of demonstration projects.

This ERANET is one of a large number of ERANETs that all aim to forward their specific field. The ERALEARN initiative of the European Commission helps ERANETs to benefit from their mutual experiences. The mapping and monitoring effort has resulted in the following three groups of joint activities[1]:

Structuring common RD&D efforts:

- Establishment of cooperation agreements
- Mutual opening of programmes
- Mutual opening of research facilities
- Design and implementation of joint R&D programme
- Design and implementation of joint calls
- Coordination of nationally funded research projects

RD&D quality assurance:

- Establishment of common evaluation procedures
- Definition of common ex-post evaluation schemes, and common schemes for monitoring
- Work on benchmarking

Human resources:

- Personnel exchange
- Joint training activities
- Mutual learning

These activities have been identified by ERALEARN. A comment that must be made, is that the majority of the ERANETs has a clear focus on R&D, while ERANET Geothermal and other energy ERANETs foster the cooperation between organisations that are both involved in R&D and in implementation activities. This results in a wider scope for possible joint activities.

[1] N.K. Özbolat, M. Boden, Netwatch mapping and monitoring: Fifth exercise, JRC-IPTS, 13/02/2013, via http://netwatch.jrc.ec.europa.eu/strategic-analysis/mapping-and-monitoring

Joint activities must be fit for purpose and be cost-effective. Within the Geothermal ERANET, our approach should be consider various potential joint activities. Joint activities can run consecutively or in parallel, and can be run by various consortia within the Geothermal ERANET. We consider the following possibilities:

JA1 Information Exchange/ Knowledge Exchange groups) - low budget

Groups to tackle issues through several means (dedicated meetings/workshops/visits/....). This can be a very effective and easy to organise way to make ensure that progress in a number of European countries is shared on a European scale.

JA2 Joint work/review – limited budget

This could be a joint assignment, e.g. to have an expert company produce a status report on a specific issue, a detailed study to solve a specific issue etc. All interested countries could bring together budget for such an assignment, which is then of benefit to all.

JA3 Joint Call – significant budget

A joint call allows stakeholders in the participating countries to work jointly on developing new insights and new systems, in contrast to the first two types of joint activities that essentially aim to improve availability of or analysis of existing information, where it is required.

The question what kind of activity is most suited for work on a specific theme should be carefully considered by the countries that wish to participate. Programme owners – the Ministries – will be interested in maximising value for money. What is the barrier we want to address, what are the opportunities that we are trying to make real? Is the proposed instrument suited to realise the objective? These questions need to be addressed.

We recommend that a realistic and pragmatic selection will be made within Work package 4, to optimise chances for early benefits, optimise benefits to all participating countries, while benefitting from initiatives that have already been developed by the participants of the Geothermal ERANET.

6. How to organise Joint Activities

How should the Geothermal ERANET organise the development of joint activities?

It is important to realise that the geological and market situations differ in the various participating countries, e.g. from a mature market with 90% of heat from geothermal, to countries where use of geothermal heat is still in its infancy (see also report D2.1). This leads to various interests of the participating countries, though we see from the WP2 work that there is much common ground as well.

For organising joint activities, a broad approach is helpful, which allows countries to embark on activities that have an added value for their own work. Any joint activity that is supported by two participating countries can be considered as a result of the Geothermal ERANET work, and its success will foster the European geothermal development. Not all countries need to participate in all joint activities. However, plans for joint activities should be discussed among the Geothermal ERANET countries, so that countries which also have an interest in a specific joint activity have a chance to join.

The joint activity should be shaped to best address the relevant challenges. The level of collaboration (JA1, JA2 or JA3) should be fit to the challenges and to the available budget. Also, an activity could start off on information exchange – JA1, but finally evolve to a joint call – JA3 - to address remaining knowledge gaps.

We propose to start where there is a common need for activities, evidenced by two countries starting an initiative. This will give us examples of collaboration and first successes. This will then be the basis for further collaboration, perhaps on similar subjects, and perhaps on new ones. Joint activities must be fit for purpose and be cost-effective. Within the Geothermal ERANET, our approach should be prioritise potential joint activities by applying these criteria.

To facilitate the organisation of joint activities, two or more proposing countries could present the headlines of the plans to the Geothermal ERANET participants, detailing for example:

- Title
- Aim
- Background (research need etc.)
- Timing (final date for joining, start and end date of actual activity)
- Nature of the joint work
- Required input per country, in terms of time and budget

- Consortium of countries, taking the initiative
- Collaborating countries
- Target community
- Dissemination of the results (e.g. through EGIP, through website ...)

Well developed and successful joint activities will strengthen the Geothermal ERANET. It can then form the basis for a lasting collaboration between European programme owners and programme managers on geothermal energy, with a focus on advancing the European geothermal market

7. The way ahead

The work in the Geothermal ERANET shows, that there is much scope for forwarding research, development and implementation of geothermal energy through European collaboration. The collaboration in Geothermal ERANET brings together the governmental interests. It complements the geothermal industry association EGEC, and the EERA-JPGE, which brings together European researchers.

Our work shows that there is a lot to gain, starting with good in-depth information exchange, but also through joint work on joint challenges. Let's jump!

APPENDIX I

A. EGIP, the European Geothermal Information Platform

The work description of the Geothermal ERANET states the objective to complete the preliminary work required to create a European Geothermal Platform with the purpose of sharing information on legal and regulatory aspects, policies, measures, institutions, research projects and data. Organising and sharing geothermal information can be important, in a strategy to foster development of geothermal energy utilisation, throughout Europe.

Work in WP3 is already ongoing on the development of EGIP, the "European Geothermal Information Platform". The reports D3.1 and D3.2 analysed the current status of available information, and proposed a three-phase approach to organise the EGIP, following the collection of useful links and documents organized within the Geothermal ERA-NET in the project website (the so-called Stage 0 of EGIP). Stage 1 of the work on EGIP is currently being implemented by some countries who volunteer to participate. It has taken the form of a joint-work (JA2 activity), and will be described in WP7. Important is that EGIP brings together information on a broad range of topics and that it is designed as an INSPIRE-compliant distributed system. The establishment of EGIP would be beneficial also to provide a transparent and common base for many of the topics described in the following sections.

Recently, the need for a common and harmonized geothermal standard for reporting geothermal resources has been raised on various occasions, and the drafting of such specification is at the moment been organized by IGA. Such a work will be an important base for the complete development of portion of EGIP related to the underground information.
More details on this work can be found in the reports of WP3, which are available from www.geothermaleranet.is.

B. Regulations

Regulations are a field where many countries experience some kind of barriers or opportunities (CH, DE, HU, IT, SI, SK, IS, NL). There is scope for learning from each other. Report D2.1 "Geothermal energy status and policy review", paragraph 3.8 presents an overview of legal aspects of realising a geothermal energy project by country. A number of countries has diverse and potentially ambiguous legislation, and there are other barriers as well.

A joint action could aim to come with a set of recommendations for amendments to the law – it should be a JA1-JA2 type of activity. However, in order to be successful, it would be necessary to find support from lawmakers and –most probably - from the geothermal industry as well.

A specific issue that needs to be mentioned here is the proposal of Iceland, to work on interoperable statistics on geothermal utilisation, and its implementation in EGIP. The work in WP2.1 underpins this need (see report D2.1, page 11). This could be a much targeted JA1-JA2 type of activity, where a European protocol for determining energy utilisation from geothermal would be the result. This will help assessing progress on geothermal and will promote credibility of the energy source.

C. Economics and risk mitigation

Nearly all Geothermal ERANET countries (CH, DE, FR, HU, IT, NL, SI, SK) report economy-related problems in getting projects going. High initial cost, the need for a fit-for-purpose feed in tariff to have a positive business case, and the need to cover somehow the geological risk are issues often mentioned.

High initial cost in principle poses a challenge for researchers and companies: can we drill geothermal wells in a more efficient way? Can we set up geothermal projects in a different way with an improved business case? How can we map the geological information, and find where projects are best realised? – all these issues are considered in the following paragraphs. In a way, it could also be a challenge for the European market. Increased transparency of the European market could help European investors realise projects with higher value for money. A first step could be to set up a register of European drilling companies as part of EGIP. This is a JA-1 activity.

An overview of public support and funding by countries has been presented in report D2.1 "Geothermal energy status and policy review". A potential joint activity could be to learn from each other, and come up with a set of recommendations for designing the public support schemes, or a specific subset of those schemes, covering the geologic risk. Just as potential work on regulations, the real success of such work would require support from our Ministries. This would be a JA-1/JA-2 type of activity.

D. New/innovative concepts and applications

A significant number of countries (CH, DE, FR, IT, IS, NL, TR) see the need to work on new concepts for the use of geothermal energy, in terms of RD&D needs, be it on innovative concepts, heat utilisation or the power cycle. Also, in terms of barriers and opportunities, many countries expect benefits from developing new concepts. The RD&D project overview (report D2.2) introduces many ongoing projects that explore new possibilities, ranging from combinations of geothermal and heat storage, to industrial applications, understanding supercritical reservoirs and utilisation of geothermal CO_2. It is important to realise that this includes new concepts for direct use and new concepts for electricity generation (where direct use is often very much required to have a favourable business case). Some topics are only relevant in a limited number of countries, for instance where there are supercritical reservoirs. Some concepts may be novel in certain countries, while there is experience on that particular issue in other European countries. Generally speaking, all innovations have the common goal to strengthen the position of geothermal energy in the market.

It is possible to envisage joint activities on various levels, when thinking about new concepts:

- JA1: to exchange information on ongoing projects. Examples could be exchange on supercritical fluids between Iceland and Italy, but also exchange between the concepts of cascading and heat storage which are in operation today.

- JA2: e.g. to gather lesson-learned from projects in a specific field.

- JA3: to organise a joint call for projects, e.g. on smart combinations with geothermal energy; either as R&D or as demonstrations. Demonstrations would need a significant budget in all countries that would participate in such a call. There could also be a topic related to electricity generation, a topic that still holds sufficient challenges for those countries that aim to increase the geothermal electricity production significantly in the years to come.

E. Operational issues

Operation of wells, avoiding corrosion, dealing with scaling and precipitation, and keeping the pumps in good operating condition. A successful geothermal project requires all of this, and but still these operational issues pose challenges. This leads to uncertainty for investors, and hampers the market. Operational issues are a theme within the barriers and opportunities (FR, HU, IT, NL, SI) , the showcase projects brought forward by Germany, and the RD&D needs identified. The issues can be distinguished in

- Operational issues, related to the impact of the nature of the geothermal waters (prevention of scaling and harm to equipment).
- Injection issues, reinjection of the cooled brine may give rise to effects such as scaling, chemical reactions, blocking of pore throats, and stresses in the subsurface.
- Pumps and components, extend the lifetime of pumps and reduce their susceptibility to failure.

Knowledge exchange is an excellent way to address some of these issues. There is much experience throughout Europe with wells that have been operating for decades – it must be possible to bring such experience to markets where operational issues are a barrier. In addition to knowledge exchange, joint research into specific problems (JA-2 type) could be a way to address operational issues. One step forward could be to review and describe in detail the operational issues and define technical gaps, which could be organized also in conjunction to EERA-JPGE (JA2 action).

Germany and the Netherlands plan to start a joint activity on operational issues, where knowledge exchange will be an important part of the work.

F. Subsurface knowledge/data

Availability of subsurface data is an important issue for realising geothermal projects. From D2.1, we find that the mining law requirements for the availability of data differ widely between countries. In some countries, data from existing boreholes are not publicly available, while in others, gas, oil and geothermal data are public 5 years after drilling. Deliverable D3.1, "Report on the state of the art and needs in regarding geothermal data and existing tools to manage them" gives complete listings on where information can be found. Deliverable D2.2 mentions a significant number of projects which develop geothermal atlases for specific regions, or provide insight in geological characteristics, relevant for geothermal.

Limited availability of existing data leads to an unnecessarily high geological risk. Various countries see various possibilities to improve the availability of data. Part of this is national work, because it requires changes to national law. Knowledge exchange could be helpful – why would not a confidentiality period of 5 years suffice in all countries, when it suffices in some?

In the ERANET, we will also be addressing the challenge to improve availability of subsurface data through making them available through EGIP (see A in this Appendix). EGIP will link to national data and work in an INSPIRE compliant way, and facilitate access to cross-border data.

Besides the problem of availability of existing data, the data may be too limited in certain places. To extend subsurface knowledge, we need tools for exploration (imaging). Improvement of such tools will be a European interest, and a joint call could be an instrument to work on this. Started November 2013, the FP7 project "IMAGE" (NL, FR, DE, IT, ES, CH, DE, IS, NO) already works on advanced exploration techniques on a European level, see section 5.1 and www.fp7-image.eu.

Another issue within subsurface knowledge/data is reservoir modelling. Sustainable reservoir use, potential interference and the reservoir behaviour during the development of the resource are the interests here. CH, FR, HU, IS, NL and SI see research needs in this area. However, the urgency of this work is rated as smaller than exploration techniques. Several ways of collaborating would be possible here, including a joint call to deepen knowledge on this issue. The focus in the various countries needs to be sufficiently similar for this.

G. Structuring the geothermal sector

In many countries, the geothermal sector is a market with few players. In such countries, the geothermal sector has a lower visibility and lobbying strength than other sustainable energy sectors. The EGEC, the European Geothermal Energy Council http://egec.info/, brings together many types of members, from cities to engineering contractors and national geothermal associations. EGEC operates on a European level, but there are not always strong national counterparts of EGEC. Within the ERANET Geothermal, Work package 5 is analysing stakeholders in the participating countries.

Organising the sector is principally a job of the sector itself. But we cannot expect a strong sector without a healthy market. An argument to interfere would be that policy makers will need the voice of the sector, too. However, this is mostly on a national level.

Seen from another angle, the knowledge of the Geothermal ERANET consortium could help structure the market by registering key players within EGIP, e.g. drilling companies, see section C of this Appendix.

H. Public, education, and data

Barriers here focus on availability of data, availability of information on geothermal energy, visibility of geothermal energy. General public acceptance issues, but also issues related to

EGS and induced seismicity are part of this cluster, in combination with the technical work in cluster I below.

Exchange of already acquired data may be very limited or not existent. Regulatory action may address this. Information exchange on the applicable legal framework is a first step for such an action.

From a different angle, the variation in reporting codes does not help the credibility of the geothermal industry. This is also being taken up in IGA. Iceland is already addressing its Geothermal ERANET partners to contribute.

Informing the public, and promoting education and training of young people on geothermal energy are important issues. Part of the work should be national, but there may be international coordination. Professional training courses can be organized at international level (JA3 activity). Research on marketing of geothermal energy, and sharing information on how and what to communicate with the public can be a useful joint work, as well as joint action on the underpinning research on EGS and induced seismicity.

I. Anthropogenic influence

This cluster could be regarded as the technical background to public acceptance issues, in particular related to EGS and induced seismicity. This is an evident important and pressing topic, seeing the ambitious targets that our countries have for increasing their electricity generation by geothermal energy.

There are already a number of research projects in our countries on induced seismicity and reservoir creation, e.g. in France, Switzerland and Germany, see D2.2. At the same time, there is a strong consensus that this is a topic for further research.

Collaboration on this issue could take all shapes, from information exchange and dedicated workshops, to joint calls – even for demonstrations.

J. Drilling

This RD&D cluster focuses mainly on cheaper and more efficient ways of drilling – which is the main cost of a geothermal project. Especially for deep drilling this is relevant, since drilling costs tend to rise exponentially with depth. Slovakia, Germany, Switzerland and the Netherlands have recent or ongoing projects on drilling technologies (see D2.2). A challenge when collaborating on drilling are IP issues – this research is very often connected to specific companies.

APPENDIX II List of ETP RHC Geothermal research priorities

Table 4 List of R&D projects proposed in the Geothermal Roadmap of the RHC-Platform (excluding shallow geothermal applications by geothermal heat pump systems

Number **[Deep geothermal GEOD..]**	**Description**
1	Create a European Geothermal resource database.
2	Exploration technologies (geochemical and geophysical exploration campaigns), characterisation and assessment of geothermal reservoirs
3	European campaign of slimholes: new technologies & drilling campaign
4	Improve current drilling technologies
5	Develop novel drilling technologies by 2020: in laboratories (by 2015), on site (by 2017), on a demonstration plant (by 2020)
6	New drilling concept: horizontal, multi-wells, closed loop systems
7	Reservoir engineering: Well design & completion, reservoir stimulation and management.
8	New Materials: corrosion, scaling
9	HT/HP tools, high temperature production pump
10	Surface systems equipment: low temperature systems, heat pumps, turbines, cooling generation (via heat absorption)
11	Establish network of complementary 5-10 European EGS test laboratories.
12	Demonstration sites in different geological settings (3 plants of 5 MWe- 10MWth), and upscale (1 plant=10 MWe- 20MWth & 1 plant=20 MWe-40MWth).
13	Training and education of new geothermal professionals specialized in EGS.
14	Public acceptance: microseismicity, stimulation, environmental impact, emissions
15	Grid flexibility: Flexible and base load electricity production from EGS plants, test on dispatchability, design regional flexible electricity system.

APPENDIX III Useful links

Table 5 Useful links

IEA GIA - Geothermal Implementing Agreement	www.iea-iga.org
IGA - International Geothermal Association	www.geothermal-energy.org.
EGEC - European Geothermal Energy Council	http://egec.info/
ETP RHC – Renewable Heating and Cooling	www.rhc-platform.org
EERA JPGE – EERA joint programme on Geothermal Energy	http://www.eera-set.eu/eera-joint-programmes-jps/15-eera-joint-programmes/geothermal/

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