Technical and non-technical barriers & opportunities

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Abstract

This report shows barriers and opportunities for geothermal development in countries, participating in ERANET Geothermal energy. These barriers and opportunities have been identified by the participants of ERANET Geothermal energy. They will be an important input in setting up a programme of international collaboration.

Executive Summary

Stimulating the use of geothermal energy as a source of renewable energy for heating and/or electricity generation is a priority in all countries in the ERA-NET Geothermal Energy. Collaboration between the countries, to address common problems, can make efforts to stimulate the market more efficient. Countries can learn from practises in other countries, and joint challenges can be taken up together.

In order to get a clear view of common market barriers and common opportunities on the geothermal market, the ERA-NET Geothermal energy conducted a survey amongst its member countries. All countries indicated about ten barriers and opportunities for market development of geothermal energy. These barriers and opportunities were discussed and clustered at a workshop.

The ERA-NET countries have much in common, and there is certainly scope for collaboration. The common clusters of barriers and opportunities that we have identified at our workshop are the following:

- Regulations
  Opportunities for streamlined procedures for licensing
- Economics and risk mitigation
  High initial investment and uncertainty of producing the expected amounts of water/steam are a financial challenge in all countries, with various instruments to address this issue.
- New/innovative concepts and applications
  Opportunities in developing and testing novel combinations including geothermal energy, including e.g. cascading of heat.
- Operational issues
  There is scope for improving know-how on operation of geothermal wells.
- Subsurface knowledge/data
  Availability of existing subsurface data is an important issue
- Structuring the geothermal sector
  National geothermal markets are often markets with a small number of players.
- Public acceptance/ visibility and dissemination / education
  Especially for enhanced geothermal systems, public acceptance is a key issue. Improving the appreciation of the role and potential of geothermal energy will support further market growth.

These clusters, together with RD&D clusters identified at a “sister” workshop, will be input for the joint activities of the ERA-NET Geothermal energy.

1 Methodology

This report shows barriers and opportunities for development of geothermal energy in countries, participating in ERA-NET Geothermal.

The “ten main” barriers and opportunities have been identified by the national representation of the participating countries in autumn 2013. More information on the ERA-NET and the country contacts can be found via http://www.geothermaleranet.is/. It was up to the participants to decide how: some worked in consultation with relevant parties in their countries, and others worked from their own observation.

The barriers and opportunities were then analysed and clustered by all participants in a workshop at the 5th project meeting in Gstaad, Switzerland. At the workshop, some countries added additional barriers and opportunities, identified at the meeting itself.

Also, we made tables with the numbers per cluster, and the assessment of importance and urgency per issue, in order to facilitate further analysis. These tables can be found in Chapter 2 and Appendix 1, and conclusions based on the tables are presented in Chapter 3.

The aim of this report is to help identifying joint interests, as a basis for organising joint activities for forwarding the RD&D and deployment of geothermal energy – a source of sustainable energy that plays a role in the 20-20-20 ambitions of all countries participating in ERA-NET Geothermal Energy.

Figure 1 Impression of a result from the clustering workshop Gstaad, Switzerland

2 Clusters by numbers

The tables below show an overview of the numbers of barriers and opportunities, identified to be part of the various clusters. In addition to these numbers, Appendix 2 shows tables, where also the importance and urgency of the various issues is taken into account.

Table 1: Number of barriers per cluster per country

	1 Regulations	2 Economics & risk mitigation			3 New/innovative concepts and applications	4 Operational issues	5 Sub-surface knowledge/data	6 Structuring the geothermal sector	7 Public and education			
		a Investment	b operational support	c risk mitigation					a public acceptance	b visibility and dissemination	c education and training	
CH	1	1		1				1	1			5
DE	1	1		1			1		1	1		6
FR			1			1	1		1	1		5
HU	2	1				2	1					6
IS								2				2
IT	2	1	1		1	1	1	1	3		1	12
NL		1		1		1		1	1	1		6
SI	1			1		1	1		1	2		7
SK	2	1	1									4
TR										3		3
	9	6	3	4	1	6	5	5	8	8	1	56

From the table, it shows that Public and educational issues, category 7, are most-mentioned issues. Category 2, Economic issues, is the second most important category when it comes to numbers of barriers.

When looking at the numbers, however, it has to be born in mind that the “weight” and “breadth” of the individually mentioned barriers and opportunities is not equal in all cases. For example, if country A has combined all financial barriers in one issue, and if country B describes exactly the same in three separate issues, the conclusion that there are “more” issues in country B will not really help our work. The purpose of this report is to find common ground for collaboration. Analysing the numbers assists this, but then, we must look at the content again. And the chances for collaboration which this content offers.

Table 2: Number of opportunities per cluster per country

	1 Regulations	2 Economics & risk mitigation	3 New/innovative concepts and applications	4 Operational issues	5 Sub-surface knowledge/data	6 Structuring the geothermal sector	7 Public and education			
							a public acceptance	b visibility and dissemination	c education and training	
CH					1	2				3
DE			1		1				1	3
FR		2	2			1				5
HU					1					1
IS	3		4							7
IT	2	2	4		2	2	1			13
NL	1		4	1				1		7
SI			1	2						3
SK							2	1		3
TR			4	1						5
	6	4	20	4	5	5	3	2	1	50

When it comes to opportunities, many countries see much scope for developing new/innovative concepts or applications. Second most important category here is the regulations. These opportunities mirror some barriers – an opportunity would be improved regulations.

3 Barriers and Opportunities

This chapter presents common barriers and opportunities, and categorised at the workshop in Gstaad at the 5th project meeting.

3.1 Regulations

Many countries experience some barriers, but also opportunities, when it comes to regulating geothermal energy. Opportunities are mostly the mirror of the barriers, and represent opportunities of streamlining and simplifying procedures.

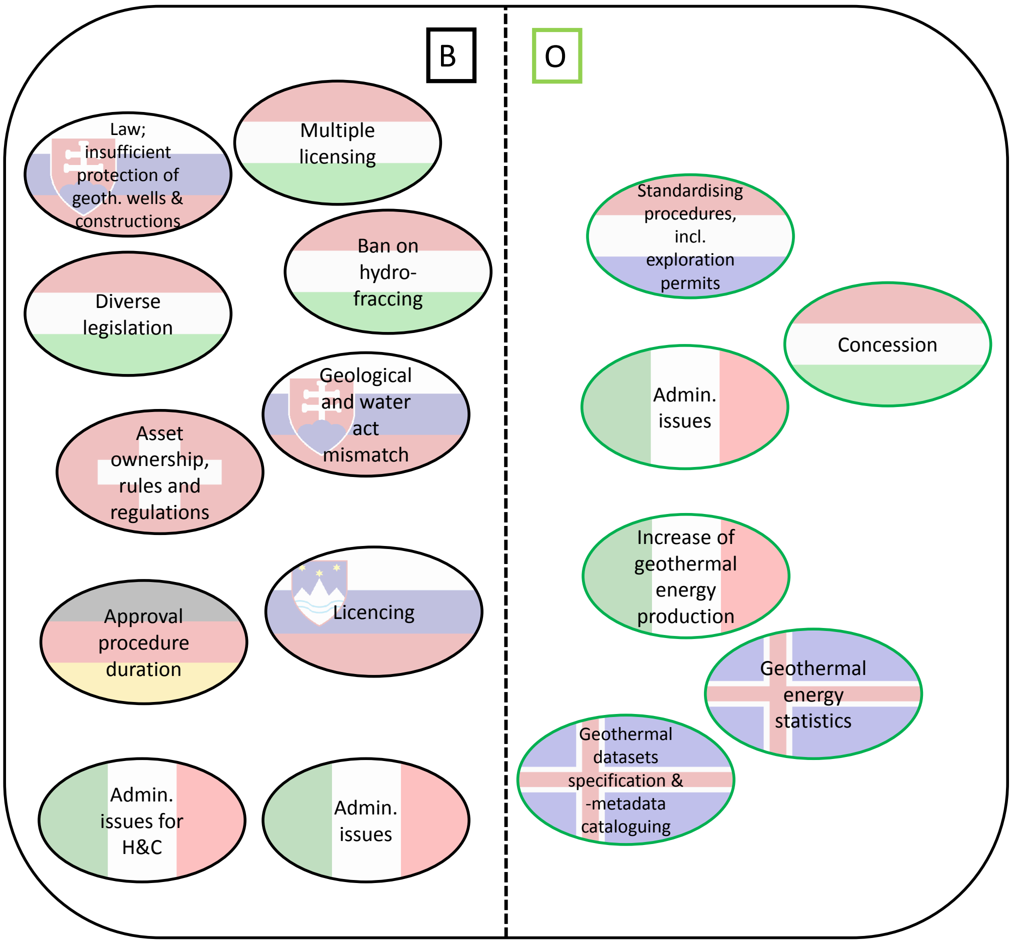

Figure 2 Regulations

Table 3: Regulatory barriers and opportunities

CH-5 U:++ I:++ S: M, U, I	Asset ownership, rules and regulations	Deep geothermal resources belong (in almost all cases) to each of Switzerland's 26 cantons. Laws governing the utilization of the subsurface are scarcely developed, processes to grant licences/leases and permits to construct and operate geothermal leases are in their infancy in a handful of cantons. Intercantonal agreement hardly exists. Regulatory authorities are not separated well from permitting and licensing authorities. No agreed upon Swiss standards for drilling deep geothermal wells, hydraulic stimulation, construction of geothermal facilities, etc. exist.
DE-2 U: ++ I: + S: U, I	Approval procedure	The time span for the different permissions is very long.
HU-1 U: ++ I: + S: U, M	Diverse legislation	Legislation is separated according to (1) way of production (with or without abstraction of thermal groundwater) and depth (-2500 m). Exploration and exploitation with water production above 2500 m is under the Act on Water Management; without water is under the Act on Mining. Below 2500 m everything is in the frame of Concession (Act of Mining) irrespective the way of exploitation (with or without water).
HU-2 U: ++ I: + S: U, M	Multiple licensing	Shared among green authorities (water) and mining inspectorates according to the above categories.
HU-6 U: + I: + S: U, I	Banning on hydrofracking	General banning on fracking which impedes EGS projects. Unconvinced politicians - despite expert materials which have been provided
IT-2 U: ++ I: ++ S: U, I, M	Administrative issues for power production	The licencing process (mining and environmental issues) is extremely fragmented, complex, and farraginous. Authorization times to obtain the necessary permits for the development of geothermal plants may take longer than what specified by law, discouraging investors [e.g. it is not acceptable to have more than one year timeframe to carry out research activities such as seismic or MT].
IT-3 U: + I: ++ S: I, U	Administrative issues for H&C and direct uses	Regulation on geothermal plants exists only for power production and it is necessary to have a clear regulation also on H&C and direct uses.
SI-5 U: + I: +	Licensing	The system of licensing for exploration and exploitation of geothermal resources does not efficiently regulate and help to develop the national geothermal sector.

S: U		
SK-2 U: + I: + S: U, I	Geological and water act mismatch	Geological Act is not in accord with Water Act. Permission for the realization of production well (not a survey one) must be issued according to the Geological Act equally as for a survey well and then in duplicate the approval process of a completed well is carried out again, now according to the Water Act.
SK-3 U: + I: ++ S: U, I	Insufficient protection of geothermal wells and constructions	In the Water Act the protection of geothermal well as well as that of the geothermal construction are not unambiguously declared. The legislature has no idea how to protect them from other activities or from the implementation of additional wells.
HU-7 U: + I: + S: U, I	Concession	A more transparent way for exploitation of medium/high enthalpy deep reservoirs, protection of users' interest.
IS-7 U: ++ I: ++ S: M	Geothermal energy statistics	Simplification of geothermal energy statistics gathering for interoperability across countries and associations.
IS-8 U: ++ I: ++ S: M	Geothermal datasets specification	Defining data tables according to spatial datasets in stage 1 in EGIP feasibility study: Temperature map, surface heat-flow, exploration and production licenses and power, map of education and research institutes and map of geothermal industries. Also definition of common data tables for geothermal areas and wells (according to INSPIRE Technical Guidelines and request for datasets in IRENA Geothermal Strategy for the Global Renewable Energy Atlas)
IS-9 U: ++ I: ++ S: M	Metadata cataloguing of geothermal datasets	Each participating country is responsible for completing datasets as defined in 9 and catalogues the metadata for the datasets in the respective official national metadata base and open access to that metadata in the EC INSPIRE Geoportal. This is subject to the finalisation of defining the data tables according to 9 by the end of 2014.
IT-18 U: ++ I: ++ S: U, N, I, R, M, S	Administrative issues	The organization of a 'one stop shop' acting as interface for consulting and authorization processes could encourage investors.
IT-25 U: ++	Increase of geothermal energy production	Companies producing energy from non-renewable sources should have a commitment to produce energy from renewables including geothermal.

I: ++ S: M, U		
NL-10 U: ++ I: + S: U, I, M	Standardising procedures, incl. exploration permits	To provide a dedicated procedure for geothermal projects, fit to their risks and operators including an exploration permit "light" dedicated to the production of water, with no unproductive hurdles and costs at the time of application. The upcoming revision of the Mining Act offers a good opportunity to work on these issues.

Table legend for all tables:

CH = Switzerland; DE = Germany; FR = France; HU = Hungary; IS = Iceland; IT = Italy;
NL = The Netherlands; SI = Slovenia; SK = Slovakia; TR = Turkey
U (Urgency): Urgent (++), mid/long term issue (+)
I (Importance): High importance (++), important (+), less important (-). Default is + (important).
S (Sector): Sector(s) that consider this an barrier/opportunity. Users/Developers/Investors of geothermal projects (U), Geothermal Industry (I), Research community (R), Government/Ministry (M), Other, defined by specific countries: Media (E), Insurance (N), Local Stakeholders (S).

Even though regulatory issues are country-specific, there are similarities, and there is scope for countries to learn from the experiences of their sister countries. In many countries, geothermal energy was not in the mind of the lawmakers at the time of writing, and amendments would help the market. Aim should be law suited for purpose, including all potential uses of geothermal, and unambiguous and homogeneous per country. The law should also protect the investment in geothermal energy against competing uses of the subsurface. Then, procedures for licensing should be straightforward, of course within reasonable limits.

Opportunities at the one hand mirror the barriers. At the other, there could be opportunities for geothermal by legislation that would require a specific percentage of renewables in the energy mix of energy companies. Others see opportunities through more clarity on statistical information. This helps assessing progress on geothermal.

In general, countries find these important and urgent issues.

3.2 Economics and risk mitigation

The high initial investment for a geothermal project and the uncertainty of producing the expected amount of water/steam due to the geological risk is a challenge in all participating countries.

In the cluster economics/risk mitigation, there are **three sub-clusters**, one related to the ***high initial cost***, one related to ***operational support***, and the last related to ***methods to cover geological risk*.**

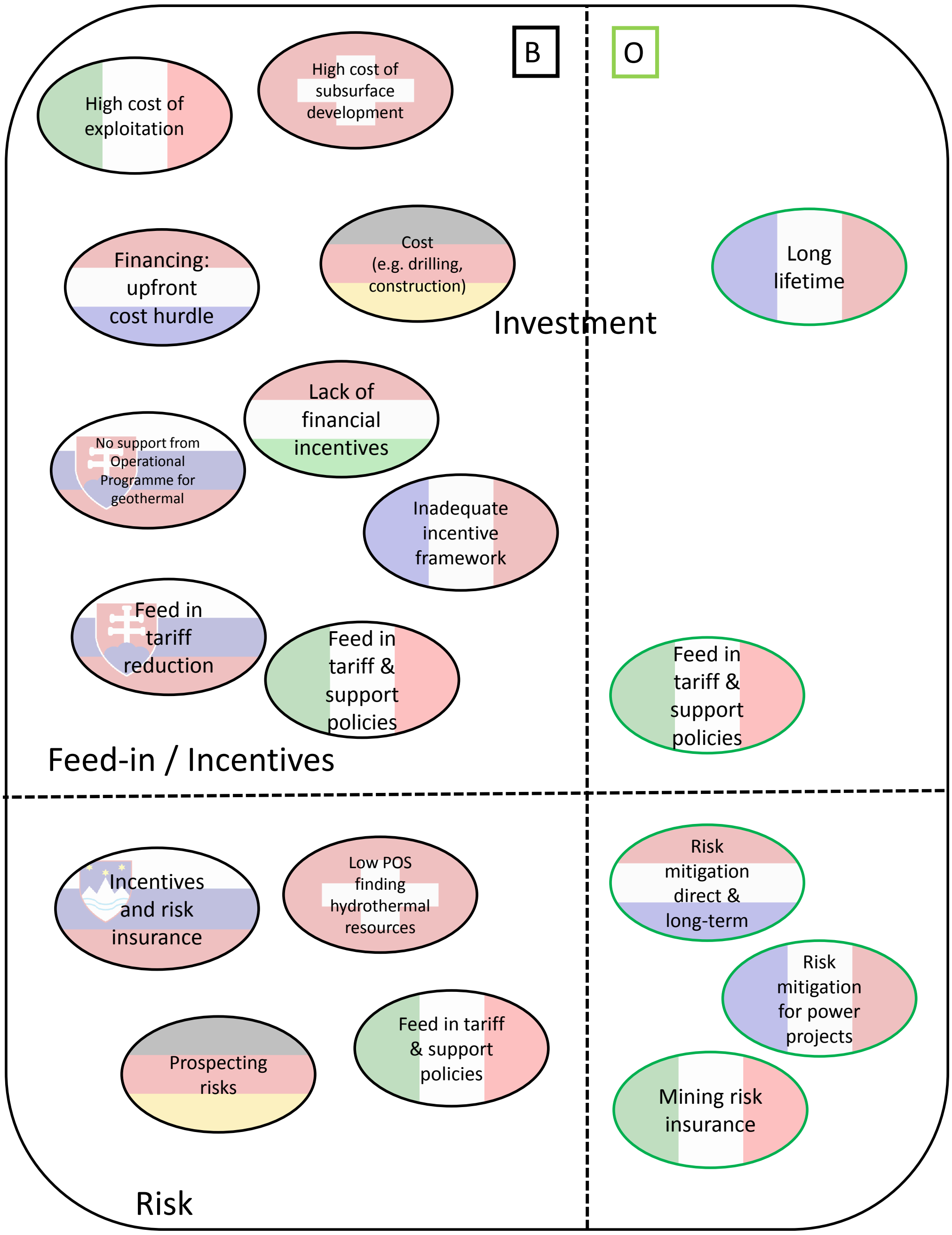

Figure 3 Economica and risk mitigation

Table 4: Economic barriers and opportunities, mostly related to investment

CH-3 U:+ I:++ S: S, U, I, R	High cost of subsurface development	The specific capacity cost for a power from geothermal energy is near €14.000 per kW_{el} and the unit technical cost of developing the subsurface is near €250 per MWh_{el} – these factors need to be cut by a factor of 3 if power from geothermal electricity were to become commercially viable by 2050.
DE-6 U: + I: ++ S: U, I, R	Costs	The costs including the drilling and the construction of the plant are too high compared to the break-even-point when it is possible to make financial profit.
HU-3 U: ++ I: ++ S: U, I	Lack of financial incentives	Except for few available grants in the Environment and Energy (Structural and Cohesion Funds) Operative Programme and recently launched EEA Grants, no financial support for projects. No risk insurance, favourable taxes etc. FIT is under revision
IT-11 U: ++ I: ++ S: U, I	Costs for resource exploitation	The costs of the exploitation of geothermal resource remain very high in terms of both investment and maintenance especially for those installations where the aquifers are located at high depth.
NL-1 U: ++ I: ++ S: U, I, M	Financing & up-front subsidies	Up front subsidies reinforce own capital (equity) and consequently facilitate financing. In the Netherlands there has been a policy shift from up-front subsidies to a Feed-in premium (FIP) mechanism. For typical Dutch projects, in horticulture, 30% equity is very high. The more so, as projects tend to become more expensive – related to increasing demands for proper drilling and operation. New potential partners might enter the market, such as pension funds and regional development banks.
SK-4 U: ++ I: + S: U, I	No support form Operational Program Environment for new geothermal wells	Utilization of financial resources from the Structural Funds of EU in the framework of the Operational Program Environment was blocked by the Ministry of Environment of Slovak Republic. To fulfil the conditions stipulated by Brussels is not a problem, but the Ministry tightened the conditions by the requirement, that the eligible applicant must possess a production well already including the approved calculation of utilizable water supply. The price of geothermal well comprises major part of the total investment.
FR-9 U: + I: + S: I	A very long lifetime that balances the significant investment costs	The wells drilled in the Parisian basin have produced heat for more than 30 years, even if a lifetime of 15 to 20 years was expected at the beginning. This is also a reality for high temperature reservoirs in volcanic areas. The same can be expected for many EGS project although it should be assessed and validated in detail. This aspect, which is quite rare in power facilities, has huge impacts on the profitability of geothermal projects.

Table 5: Economic barriers and opportunities, mostly related to operational support

FR-5 U: + I: + S: I	Inadequate incentive framework	The structure of the costs of a geothermal project is very special: high investment costs and low operating costs as hydro, but with a geological risk in addition. That induces the need of specific incentives to promote geothermal energy, which are not always in place. For instance in France, the framework in overseas department is today inadequate, so that only very few projects are emerging. The feed-in tariff is very low (lower than the price fossil electricity is produced) and there is no risk mitigation scheme. It is also important that the local communities share a part of the benefits of the projects, through tax or other tools.
IT-12 U: ++ I: ++ S: U	Feed-in-tariff and support policies	The sector reflects the significant uncertainty related to the framework of Italian incentives post-2015, which is still undefined. This aspect is irreconcilable with the long development times of geothermal projects, which is significantly higher than other renewable. For the geothermal sector, markedly capital intensive, it would be necessary to identify and implement risk mitigation mechanisms and policies to support the crucial phase of drilling. The decision to offer an indirect coverage to the relative mining risk by applying feed-in-tariff in a situation far from being defined (see point 1) is not adequate.
SK-1 U: ++ I: ++ S: U, I	Feed in tariff reduction	The feed in tariff for geothermal power was significantly reduced in 2013 (from 190,51 to 155,13 €/MWh) even though no geothermal power plant was built in Slovakia up to now.
IT-16 U: ++ I: ++ S: I, U	Feed-in-tariff and support policies	In order to enhance the sector, the definition of a regulatory framework, which takes into account of unused quota of incentives available for geothermal energy in the period 2013-2015, is strongly needed.

Table 6: Economic barriers and opportunities, mostly related to risk mitigation

CH-1 U: ++ I: ++ S: I	Low POS finding hydrothermal resources	Technical: Only 10-12 wells have been drilled to depths larger than 3000 m
DE-3 U: ++ I: ++ S: U, I, R	Prospecting risk	The risk of drilling into an insufficient reservoir is still too high.
NL-2 U: ++	Risk mitigation	Banks are hesitant to finance geothermal projects, because they perceive risks they cannot quantify. This is not only the geological risk, but also the long-term operation risk. The present guarantee fund does not cover 85% in all cases, because there is a cap on maximum support and project costs have

I: ++ S: U, I, M		risen in general.
SI-2 U: ++ I: + S: U	Incentives and risk insurance	Recommendations for financial incentives are apparently the most unexploited or unknown lever for the stimulation of geothermal resource development. The risk insurance supporting instrument is not available in Slovenia.
FR-10 U: + I: ++ S: I	Risk mitigation schemes for power projects	France has a very efficient rick mitigation scheme for projects directly using geothermal heat. A similar scheme should be put in place for power projects. The possibility to extend these schemes to projects abroad should also be taken into consideration.
IT-15 U: ++ I: ++ S: I, M, U, N, R, S	Mining risk insurance	Specific procedures and public assistance covering the mining risk have to be foreseen. Involvement of financial-insurance stakeholders prior (but not only) the development policy, with the aim of identifying and creating technical and economic conditions, can improve the management of the mining risk.

Many countries report problems in getting projects going, related to financing the projects. Depending on the financial buffers of a typical company investing in geothermal, the investment cost may be an issue. The geological risk is an issue, especially in areas and at depths where there are few wells. Some countries provide soft loans, which is a support through the investment cost issue and the risk mitigation in one step. Subsequently, producing sustainable electricity or sustainable heat may be viewed as an important public good. All countries have feed in tariffs or feed in premiums for electricity in place – though these instruments are not ideal and often ignore sustainable heat.

Opportunities for collaboration can certainly be to study the risk guarantee schemes in more detail, or to investigate what might be possibilities for a European fund on this issue. Another way of looking at the same is to work on methods to improve the probability of success when drilling. However, 100% guarantee can never be expected.

An approach from a different angle could also be worthwhile for addressing economic issues: cost comparisons could help drive cost down and show what the uneconomic top really is.

Again, countries find these barriers and opportunities important and urgent.

3.3 New/innovative concepts and applications

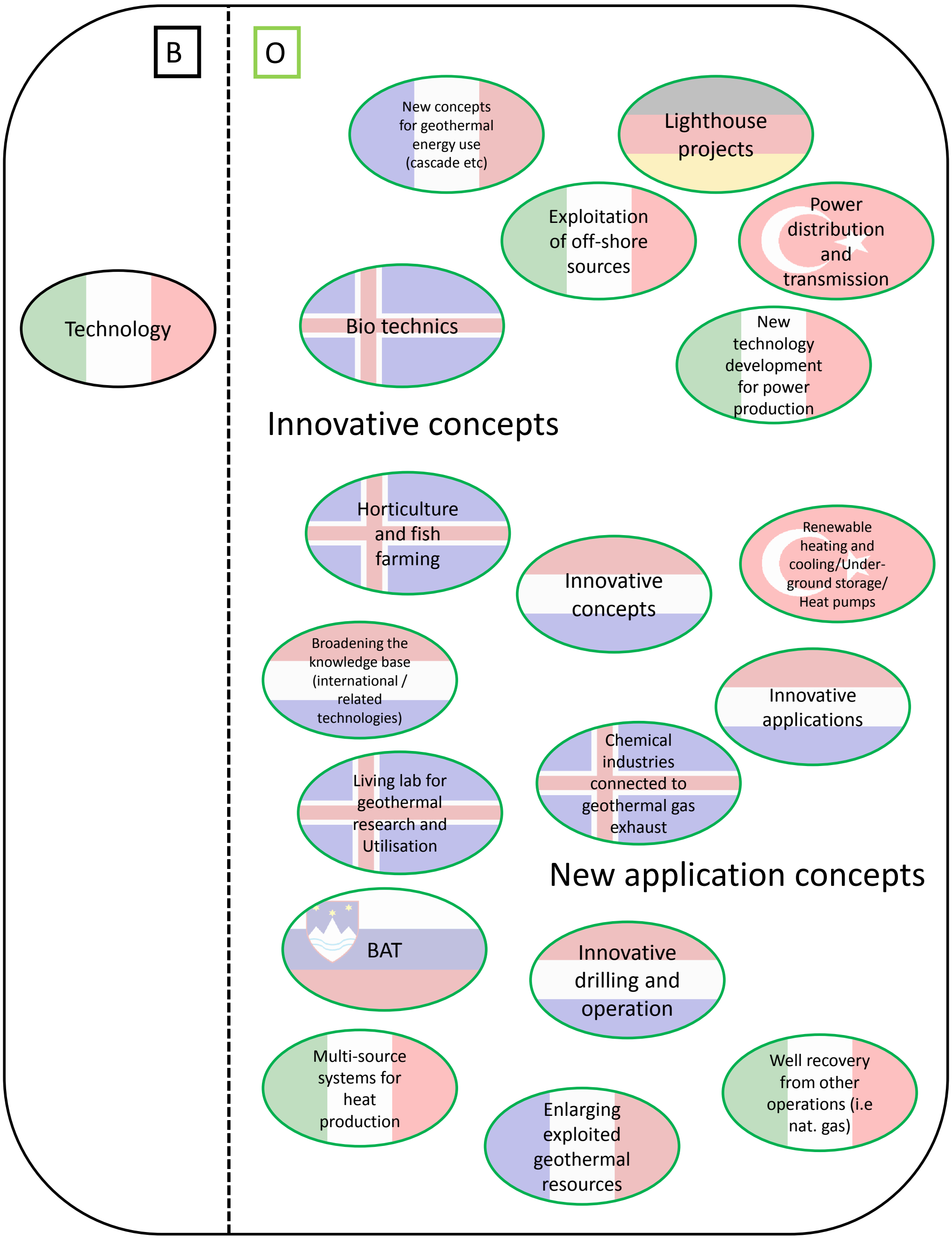

Figure 4 New/innovative concepts and applications

Table 7: New/innovative concepts and applications

IT-9 U: ++ I: ++ S: U	Technology	The use of conventional techniques restricts the exploitation of geothermal sites only to medium-high enthalpy resources. Moreover, there is a lack of technologies for the sustainable use of the geothermal resources.
DE-9 U: ++ I: ++ S: R, M	Promote the advantages of GT with a "lighthouse"-project	It still has to be shown that geothermal energy is a valuable technique to produce a significant amount of energy.
FR-7 U: + I: + S: I	Enlarging the exploited geothermal resources; New concepts for geothermal energy	Various resources should be exploited to extend significantly the contribution of geothermal energy in the mix: intermediate and deep aquifers in various regions, with various geological, hydrogeological and geochemical characteristics; various high temperature reservoirs with magmatic and amagmatic heat sources. This can be achieved through a public support to demonstration operations that should be accompanied by R&D activities.
FR-8 U: + I: + S: I, U	Developing various uses of geothermal heat	In addition to power production, cascade heat uses or cold production through the use of sorption heat pumps should be developed: this leads to promote other uses of geothermal energy that brings a direct benefit to the neighbourhood of the project, which is a step towards public acceptance and a more local energy management. To this end, district heating must be developed in parallel.
IS-3 U: + I: + S: I, U, M	Horticulture and fish farming	Due to depreciation of the Icelandic currency the export value of various fish and vegetables products is high enough to meet requirements of sufficient rate of return.
IS-4 U: + I: + S: I, U, M	Bio technics	High educational level and innovative thinking in Iceland has led to a variety of biotechnical companies in Iceland, founded on the bases of geothermal heat and chemicals originated from geothermal fluids. http://www.bluelagoon.com/clinic/, http://www.orfgenetics.com/ there are opportunities to flourish that even further.
IS-5 U: + I: + S: I, U, M	Chemical industries connected to geothermal gas exhaust.	There is a good potential to make use of the different chemicals originating in the geothermal gases for all kinds of industrial processes. A good example of that is the Carbon Recycling International fuel produces, which is linked to the Geothermal Power Plant in Svartsengi Iceland. www.cri.is
IS-6	Living lab for geothermal research	Iceland is an ideal place for a research and test centre for multi-use of geothermal heat with its abundant geothermal resources and already

U: + I: + S: I, U, M	and utilisation.	established companies built on direct use of these resources.
IT-17 U: ++ I: + S: M, R	Multi-source systems for heat production	In areas where the characteristics of geothermal resource do not allow its use as the sole source of energy, it is still possible to integrate multi-source systems by using locally available RES.
IT-20 U: ++ I: ++ S: U, I, R	New technology development for power production	The development of new technologies (e.g. EGS) could allow to overcome many barriers that hinder the geothermal diffusion and, in particular, the limited availability of usable sources. Moreover, the exploitation of low-enthalpy resources offers a new perspective to extend the geothermal utilization.
IT-22 U: + I: + S: U, R	Well recovery for natural gas extraction	A way to reduce the installation costs in areas with high heat flow that could be recovered from existing wells (previously drilled for other purposes as natural gases extraction).
IT-23 U: + I: + S: U, I, R	Exploitation of the off-shore sources	An interesting opportunity for the geothermal development is represented by the off-shore sources, still not exploited. The technology for the development and exploitation of off-shore wells could be derived from the hydrocarbon and natural gases mining.
NL-9 U: ++ I: + S: U, I, R, M	Broadening the knowledge base – international, related technologies	The Dutch knowledge base on geothermal is being built up, but there is a chance to learn more from international experience with geothermal energy and experience in related field (oil and gas).
NL-11 U: ++/+ I: + S: U, I, R	Innovative drilling and operation technologies, incl. load management	Innovative drilling (e.g. composite, place casing while drilling) and operation techniques have a potential to bring costs down and minimise operational problems, optimise utilisation of the geothermal source (buffers, peaks).
NL-12 U: ++/+ I: + S: U, I, M	Innovative applications	Applications in buildings, district heating, industry

NL-13 U: ++/+ I: + S: U, I, M	Innovative concepts	Innovative concepts, low temperature and cascading, “ultra deep” projects.
SI-9 U: + I: + S: U, R	Best available technology	Surface installation and well’s maintenance is often poor as investments are done only when failures occur. Modernization of surface systems (HEX, etc.) is needed at user’s side. New geothermal wells should be preferred over re-drilled abandoned gas/oil wells as they are technically more efficient and give less exploitation risk due to the use of proper materials and well design adjusted for thermal water production.
TR-4 U: + I: + S: I	Renewable heating and cooling	All types of relevant studies under this title are important in order to reach a high level of geothermal development.
TR-5 U: + I: + S: I	Underground storing	All types of relevant studies under this title are important in order to reach a high level of geothermal development.
TR-6 U: + I: + S: I	Heat Pumps	All types of relevant studies under this title are important in order to reach a high level of geothermal development.
TR-7 U: + I: + S: I	Power distribution and transmission	All types of relevant studies under this title are important in order to reach a high level of geothermal development.

Smart combinations is probably a suitable keyword for the common ground in the fields of new concepts/new applications sketched in the table above. Importantly, this includes cascading of heat. But also the production of chemicals/gases which surface together with the geothermal waters or steam. The exploration of the potential of these concepts and applications broads the basis of geothermal, potentially improves the business case and therewith the chances of broad deployment. On the other hand, smart combinations introduce complexity, which might make it more difficult to get projects going.

The “innovative concepts” are not considered the most pressing barriers and opportunities. However, this should not discourage international collaboration. A game-changing innovation will have its own urgency.

Countries really see many opportunities here, and several approaches to move this forward could be envisaged: sharing knowledge, joint exploration of possibilities, and also joint R&DD on these issues.

3.4 Operational issues

A number of countries reported operational issues as barriers for further deployment. This is about operation of wells, avoiding corrosion, dealing with scaling and precipitation, keeping the pumps in good operating condition, and so on. It appears that there is a world to gain in sharing this kind of experiences.

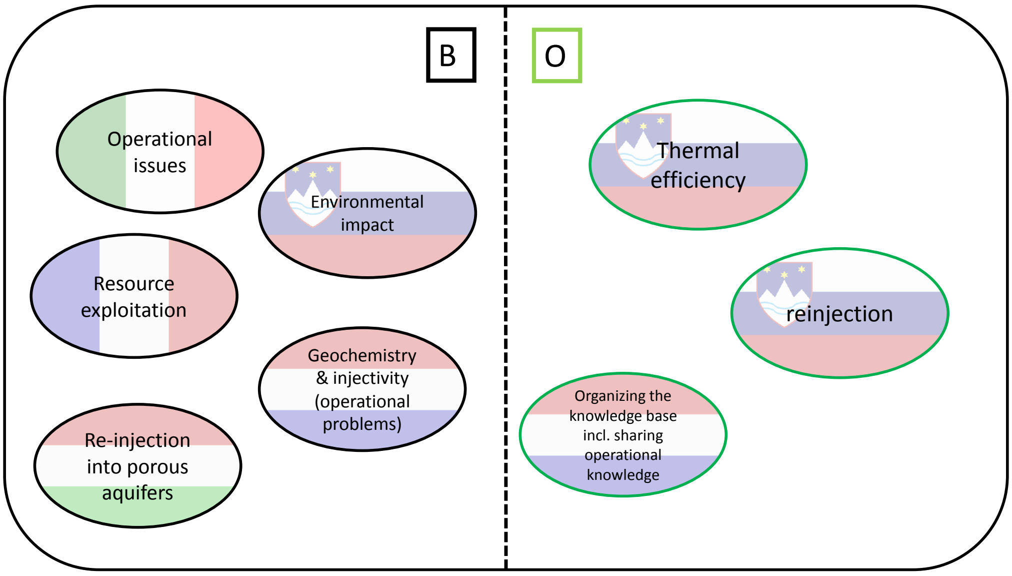

Figure 5 Operational issues

Table 8: Operational issues

FR-2 U: + I: + S: I	Resource exploitation	The proper technology must be chosen, sometimes developed and validated, to prevent various phenomena that reduce the performance or the lifetime of geothermal operations: scaling, corrosion, microbiological development, decrease of productivity/injectivity in the reservoir… The technical solution can rely on well architecture, chemical products, relevant exploitation parameters...
HU-4 U: + I: +	Re-injection into porous aquifers	Much of the Hungarian reservoirs are in clastic aquifers, where re-injection is hardly working due to plugging of the pore-throats. Only a few re-injection wells operate, significant amount of thermal water abstractions threatens sustainable production (drops in yield and pressure)

S: U		
IT-14 U: ++ I: ++ S: I, U, S	Operational issues	Once you have found the resource and started its use, the geothermal features of the area are known, but its long-term behaviour (temperature and flow rate of the resource) and the chemical characteristics of the fluids are still unknown and may lead to various problems in the management facilities (e.g. corrosion, scaling, well dimensioning).
NL-4 U: ++ I: ++ S: U, I, R, M	Geochemistry & injectivity – (operational problems)	Geochemistry issues including operational risks of scaling, corrosion and reduction of injectivity are currently considered to be an issue requiring careful, pro-active R&D as well as operational guidelines.
SI-4 U: + I: ++ S: U, M	Environmental impact	Impact of geothermal water abstraction is evident by regional deterioration of quality state in some aquifers, while decrease of piesometric level and the impact of geothermal effluent to the surface streams is more widely acknowledged.
NL-8 U: ++ I: + S: U, I, R, M	Organising the knowledge base incl. sharing operational knowledge.	There is a fairly good – though informal – interaction, exchange of information and alignment of priorities between a) government and the geothermal sector and b) between the various sections within the geothermal sector. The current practise demands intensification as geothermal energy increases in importance.
SI-8 U: + I: + S: U,M	Thermal efficiency	Users should extract as much heat from geothermal water as possible. Higher thermal efficiency thus leads to a reduction in the total amount of abstracted thermal water, as well as lower thermal and chemical pollution of the surface streams into which waste water is emitted.
SI-10 U: ++ I: ++ S: R, M	Reinjection	The use of doublets should be enhanced when only heat is extracted. This will enable more new users in the same area with less environmental impact and so also increased economy of the region (by having more greenhouses etc.).
TR-5 U: + I: + S: I	Underground storing	All types of relevant studies under this title are important in order to reach a high level of geothermal development.

The table above shows that operational issues are a very common impediment for geothermal energy. For some countries, these are really pressing issues as well. A stable long term production is not self-evident, even though there is much experience throughout Europe with wells that have operated for decades. Depending on the geochemistry, operators need to take measures to optimise production and injection. Especially injection may hamper. Re-injection is an area of interest in itself, since some countries have a tradition of production-only, with related environmental concerns. Re-injection improves the sustainability of a geothermal project, but also introduces challenges. Challenges, however, which are similar to the challenges that are shared by geothermal projects all over Europe. Slovenia draws the attention to the fact that an efficient thermal design enables more benefits from the operation of the wells.

There is a need for information exchange and possibly also for research for remedying operational issues.

3.5 Subsurface knowledge/data

Availability of existing subsurface data is an important issue for realising geothermal projects. Without detailed information considering the subsurface, it is impossible to plan a geothermal well.

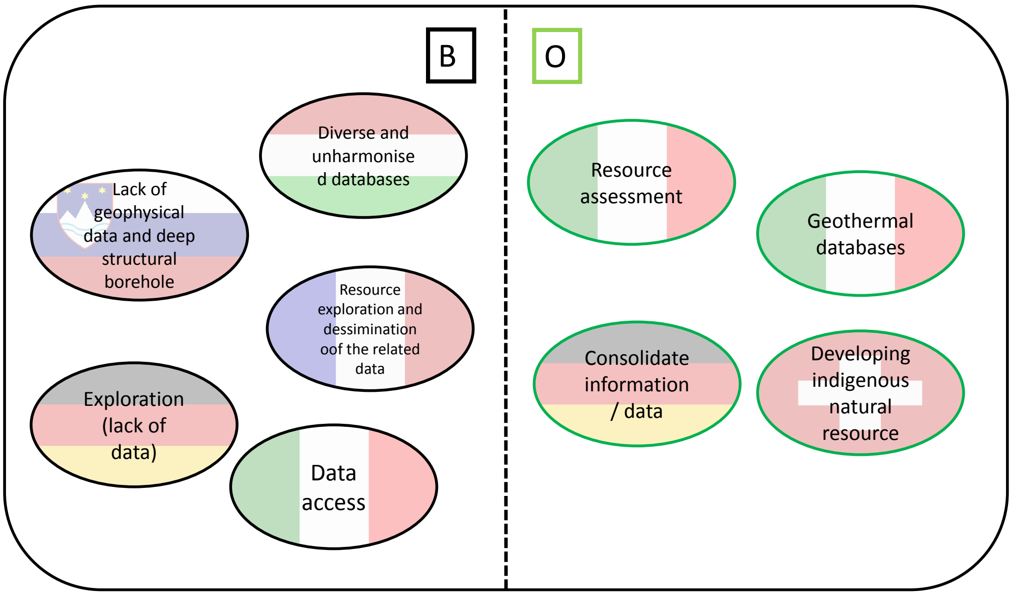

Figure 6 Subsurface knowledge/data

Table 9: Subsurface knowledge/data

DE-4 U: + I: +	Exploration	The database outside the areas of hydrocarbon exploration in the 60s-70s is very fragmentary.

S: R		
FR-1 U: + I: + S: I	Resource exploration and dissemination of the related data	The poor knowledge, characterization and evaluation of the various geothermal resources lead to a high geological risk for geothermal projects. The dissemination of the available information is needed. Further exploration is needed, sometimes including drilling. A public support is more than welcome and in this case the data and results of these exploratory works can more easily be public.
HU-5 U: ++ I: + S: U, I	Diverse and unharmonized databases	No national register on geothermal energy. Thermal water production data handled by the water authorities, while some data (only those which are relevant to pay mining royalty, after the exploited amount of thermal water solely for energetic utilization) are handled by the Hungarian Office for Mining and Geology. Many wells are overlapping with controversial data.
IT-4 U: ++ I: + S: U, I, R	Data access	There is a strong presence of the incumbent at the administrative level. An example is the management of the competitions or the difficulty/impossibility of finding geothermal underground data of dismissed mining leases (data are supposed to be public after 2 years by the end of concession).
SI-11 U: + I: ++ S: ..	Lack of geophysical data and deep structural boreholes	[no detailed description available]
CH-6 U: + I: ++ S: all	Developing indigenous natural resources	Switzerland's geothermal resource potential is considered very large, albeit of low quality vis-à-vis international standards and resource qualities. Converting resources into commercially viable reserves will unlock this vast potential.
DE-8 U: ++ I: ++ S: R, M	Consolidate information/data	Information and data exchange is necessary within the community to find solutions for general problems. Also the communication with the hydrocarbon-industry may help to use synergistic effects.
IT-21 U: ++ I: ++ S: U, M	Geothermal Databases	Organization and collection of all the available geothermal data, including those public and private from the dismissed mining lease (as VIDEPI Project for hydrocarbon resources).
IT-26 U: ++ I: + S: U, I,	Resource assessment	The Italian territory offers important geothermal resources allowing a significant development of exploitation projects. An accurate resource assessment could be favoured by an easier access to (geothermal) underground data.

R, M		

Improving the availability of existing data as well as increasing the absolute amount of data will improve the chances for geothermal energy. Various countries see various national possibilities to do so. These are often national possibilities, since the availability is regulated in national law.

In the ERA-NET, we will be addressing the issue of improving access to existing data through the work on EGIP, the European Geothermal Information Platform, which will link to national data and work in an INSPIRE-compliant way. The ERA-NET will implement a pilot to demonstrate the concept, and will investigate the possibilities of publishing a specific joint call.

3.6 Structuring the geothermal sector

The geothermal sector is often a market with few players. European collaboration could probably help the market forward.

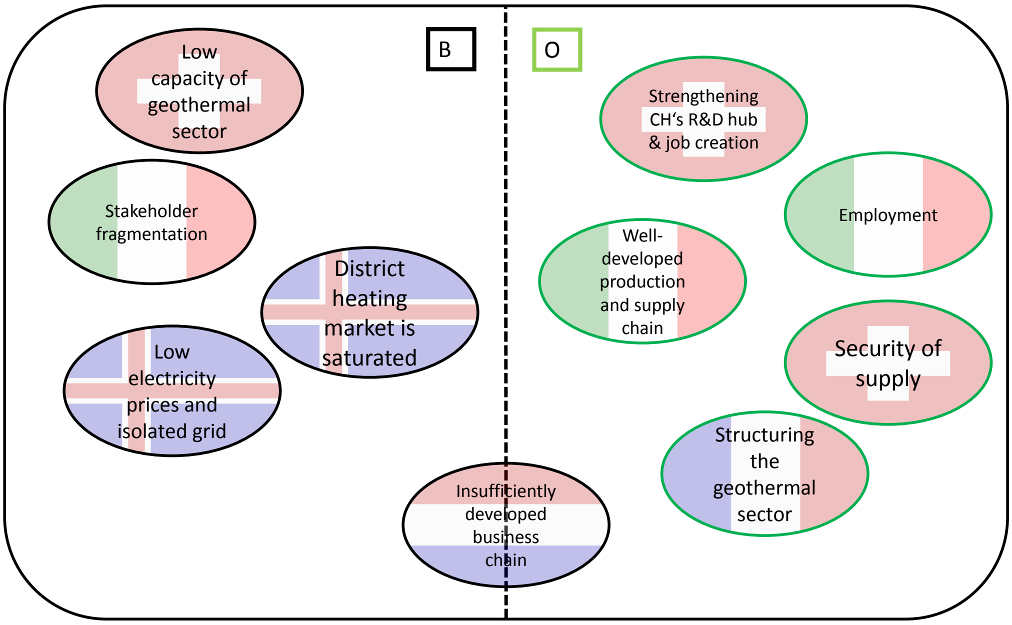

Figure 7 Structuring the geothermal sector

Table 10: Structuring the geothermal sector

CH-4 U: +	Low capacity of industrial sector to build, own and operate deep geothermal	Swiss industry treats deep geothermal energy projects as classic civil engineering and construction projects. Capabilities to managing and reducing uncertainties and their impact on project economics are limited. Due to

I: ++ S: U, I	energy facilities	relatively few projects, the service industry is also in its infancy.
IS-1 U: + I: ++ S: I, U	Low electricity prices and isolated grid	The main market constrain in Iceland is the fact that the electricity grid is isolated from the main grid in Europe. Today the power intensive consumers are more than 80% of the total market.
IS-2 U: + I: ++ S: I, U	District heating market is saturated	For over 50 years the state has supported the building of geothermal-based district heating systems which had led to well over 90% of buildings heated with geothermal energy. The potential growth is hence limited although still some opportunities can be found.
IT-5 U: ++ I: ++ S: all	Stakeholder fragmentation and self-referentiality	The geothermal stakeholders are poorly interconnected and linked by a shared strategy, in particular in the financial/insurance and communication sectors and that is a disadvantage. The project development results fragmented, complex and dispersive.
NL-5 U: + I: + S: U, I, M	Insufficiently developed business chain	Insufficiently developed business chain with too few players
CH-7 U: + I: ++ S: M	Security of supply	Switzerland's growth potential for indigenous energy supply is limited. A more distributed supply will strengthen the resilience of Switzerland's energy system.
CH-8 U: + I: ++ S: R	Strengthening Switzerland's role as a research and technology hub; creation of jobs	Switzerland's tertiary education sector (especially in the Natural and Engineering Sciences) fuels the country's economic growth – unimpeded by recent crises in Europe and other OECD countries.
FR-6 U: + I: ++ S: I	Structuring the geothermal sector	The geothermal sector needs to be more structured, to be in a comparable position for lobbying that the wind or solar energies. In addition, that allows the combination of underground and surface technologies. It is also essential to develop project abroad because an integrated offer can thus be built. A strong cluster is needed and public support is an efficient tool by encouraging cooperation. In France, strong references exist on geothermal district heating.
IT-24	National technological production and supply	In Italy there is an important technological production and supply chain, which is able to cover every sector of the geothermal project development, from research to plant realization, including all the technical services for

U: + I: ++ S: U, I	chain	exploration.
IT-27 U: ++ I: ++ S: I, R, U	Employment	The improvement of education and training activities fosters job opportunities in the industry.

The above table shows, that many countries see potential for improving the structure and the operation of the geothermal sector in their countries. There are opportunities for the sector to become stronger, through organising itself and internationalisation. There will be additional jobs in an expanding sector.

In many countries, the geothermal sector has a lower visibility and lobbying strength than other sustainable energy sectors. Question is, in how far the ERA-NET geothermal consortium (managers of geothermal programmes) could and should help change this situation. Organising the sector is principally a job of the sector itself. But we cannot expect a strong sector without a healthy market. An argument in favour of supporting the sector in organising itself is that policy makers need the voice of the sector as well, so that they know which impediments need to be addressed.

There is yet another possibility that springs to mind: the ERA-NET could help transparency in the European market, e.g. by establishing a register of drilling companies. This would make it easier for investors to ask and compare different quotes. Such a register could be coupled to EGIP.

3.7 Public acceptance / visibility and dissemination / education

If we want geothermal energy to supply an increasing share of our energy demand, we need the collaboration of the general public. This is not self-evident. In many countries, the general public is not aware of the role of geothermal energy. The visibility is limited and only experts are educated in geothermal energy. In this constellation, the threat of changes in the public perception on geothermal energy is a serious concern.

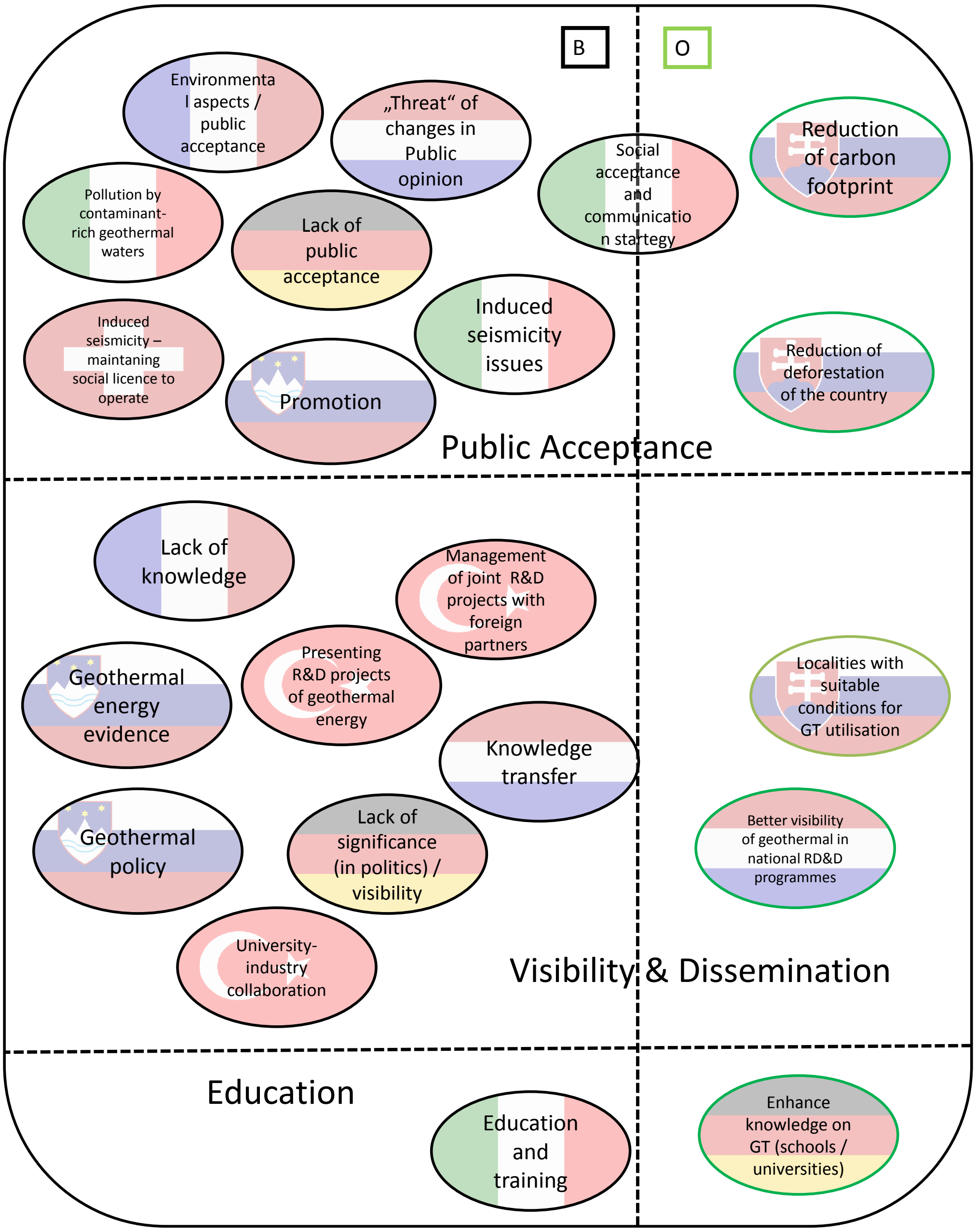

Figure 8 Public acceptance / visibility and dissemination / education

Table 11: Public acceptance

CH-2 U: ++ I: ++ S: S, U	Induced seismicity – maintaining the social licence-to-operate	Felt seismicity as a consequence of hydraulic stimulation or as of recent related to a borehole intervention is a major operational risk for deep geothermal energy projects.
DE-1 U: ++ I: ++ S: U, I, R	Lack of public acceptance	The main focus in the media and the public perception lies on the negative aspects of geothermal energy (Seismicity, Radon etc.).
FR-3 U: + I: + S: U	Environmental aspects and public acceptance	Despite geothermal energy is a renewable energy, it induces environmental impacts as every energy plant. These impacts must be assessed, notably through life cycle assessments. Sometimes this assessment and the identification of the best practices to protect the environment demands heavy studies, technological developments and validations. This environmental excellence is a first step towards public acceptance, but information and consultation of the various stakeholders is important too.
IT-6 U: + I: ++ S: U, I, R, M, E, S	Social acceptance and communication strategy	The poor knowledge (or conversely, excessive misinformation, sometimes instrumental) by the involved people can lead to strong local opposing actions, reducing the feasibility of the project and the interest of investors. Negative view on the environmental aspects can lead to negative impact on social and political aspects (lack of communication strategy). Few people know about the potential opportunities in the sector and the positive impact terms of investment and employment.
IT-8 U: + I: + S: U	Pollution	The geothermal fluid wastes are often contaminant-rich. If not well managed, they can have a relevant environmental impact and can be considered a barrier for the development of geothermal technology.
IT-10 U: + I: + S: M, R	Induced seismicity issues	The exploitation of geothermal resources can produce induced seismicity. This represents a strong barrier for both social and technical aspects.
NL-6 U: + I: + S; U, I, M	Threat of changes in public opinion on geothermal energy	The public opinion on geothermal energy is very favourable at this stage. However, there is significant public concern about shale gas, and induced seismicity incidents due to fossil fuel exploration & production. Geothermal development may be negatively affected by public wariness of subsoil activities and induced seismicity, especially when deeper projects are realised. Impact on (monitoring) costs.
SI-6	Promotion	In Slovenia there is no independent expert body (competent professional body) responsible for promotion and development of the geothermal energy

U: ++ I: + S: R		sector.
IT-19 U: ++ I: ++ S: all	Social acceptance and communication	Technical-scientific communication features strengths and solutions of weaknesses, motivates and engages local communities and policy. Hypothesis on the use of unconventional methods borrowed from marketing.
SK-6 U: + I: + S: U, M	Reduction of carbon footprint	Currently, for district heating in Slovakia, natural gas is the most common energy source. Wide geothermal direct heat will support our independence from imported Russian natural gas and reduce carbon footprint form natural gas utilisation.
SK-7 U: + I: + S: U, M	Reduction of deforestation of the country	In recent years, many district heating companies replaced coal for biomass which decreased fossil fuels consumption. On the other hand, deforestation of the land occurred in some areas. Geothermal district heating will help to afforest these areas.

Table 12: Visibility and dissemination

DE-5 U: + I: ++ S: U, I	Significance	The politics is focused on other renewable energies. Due to this lack of interest for geothermal energy, additional investors cannot be found. One running project without significant problems is necessary to gain interest.
FR-4 U: + I: + S; M, U, ..	Lack of knowledge about geothermal energy	The existence of huge amounts of energy below our feet is less evident than wind or solar energy in countries without active volcanism. Moreover, the picture that each of us has of the underground is very different and quite often not correct. At the end, the various stakeholders (public deciders, bankers, neighbours…) have a poor and distorted vision of the nature of geothermal projects and of the geothermal potential. This is also illustrated by the poor debate that took place in France about hydraulic fracturing.
NL-3 U: ++ I: ++ S; U, I, R, M	Knowledge transfer	(lack of funds for) a collective information hub and knowledge transfer is a serious constraint. It is very costly when each user and/or provider of products and services has to privately finance access to operational experiences or research data.
SI-1 U: ++	Geothermal policy	Proactive geothermal policy is missing. There is no political will to define more ambitious goals and to prepare geothermal action plans. It is not defined how we will achieve in NREAP set goals. Concession procedure for utilization of geothermal water is not effective (the duration of procedure is

I: ++ S: M, U		too long, because in legislation there are no time limitations). This holds back incentives as well as investments.
SI-3 U: + I: + S: M, R	Geothermal energy evidence	Poor evidence of geothermal energy contribution to RES share in energy balance (2020 goals). There is a very insufficient inventory about water-source heat pump utilization and no inventory about ground-coupled heat pump utilization.
TR-1 U: ++ I: ++ S: I	Management of joint R&D projects with foreign partners	Especially from the side of industry, there is not sufficient number of joint R&D projects.
TR-2 U: + I: + S: R, I	University- Industry collaboration in relevant R&D areas	The transfer of the knowledge from university to industry should be expedited.
TR-3 U: + I: + S: I	Presenting R&D projects of geothermal energy	Especially from the side of industry, the private firms should be more active in implementing R&D projects.
SK-5 U: + I: ++ S; U, I, M	Localities with suitable conditions for geothermal energy utilization	There are localities in Slovakia with suitable geological conditions and district heating systems/other centralised heat consuming system existence, which gives good prospect to geothermal energy utilization.
NL-7 U: ++ I: + S: U, I, M, R	Better visibility of geothermal energy in national RD&D programmes	Geothermal energy is only implicitly included in energy innovation instruments. However, there is a substantial increase in collective research efforts, and through channelling these efforts, RD&D on geothermal could get a more consistent base and funding. The sustainable energy policies today explicitly consider the role of heat in the energy mix.

Table 13: Education and training

IT-13 U: ++ I: ++	Education and training	Scarce existing training and the lack of high skilled HR in the industry as, instead, expected from forecasts.

S: I, R, U		
DE-7 U: + I: + S: U, R	Enhance knowledge on geothermal energy	Basic knowledge should be imparted in schools and universities especial in non-geoscientific academics to enhance the understanding of geothermal energy production in the public.

Public acceptance of geothermal energy production is problematic, or a potential change for the worse in public perception is considered a threat to geothermal energy development. Induced seismicity is the most important fear, and a related issue is fracking for geothermal energy. There are other concerns as well, e.g. dealing with geothermal waters with high loads of dissolved material. In some countries, these are really high urgency and high importance issues.

Understanding and predicting induced seismicity is an important research focus, to underpin the debate with current insights. International collaboration on this issue should be promoted.

However, technical insights alone will not convince the public. Geothermal energy has a low visibility in many countries; people are not aware of the possibilities and the potential benefits. This low visibility extends to policy makers. Addressing the lack of visibility does not seem to be an action for a European programme, however pressing the issue is nationally; this work had better be taken on by each individual country. Sharing information on how and what to communicate might be of interest.

When it comes to education, educating young people about the nature of geothermal energy generation will help public acceptance.

Appendix 1 “Further overviews”

Further sub clustering

In the process of analysing the input from the various countries, we have prepared a number of tables, which show further detail on the numbers by cluster. In the table below, one recognises the same clusters as presented in the main report, but also some “sub clusters”, that we have defined to facilitate the analysis process. These “sub clusters” were not discussed at our Gstaad workshop, but they are the result of a desk analysis of the input.

Table 14: (Table A.1 Barriers) Clusters and sub clusters by number of issues

	CH	Germany	France	Hungary	Iceland	Italy	NL	Slovenia	Slovakia	Turkey	Total
Regulation	**1**	**1**		**2**		**2**		**1**	**2**		**9**
Law	1			1		1			2		5
Licence		1		1		1		1			4
Economic	**1**	**1**		**1**		**1**	**1**		**1**		**6**
feed-in				1			1				2
high cost	1	1				1			1		4
economic operational support			**1**			**1**			**1**		**3**
feed-in			1			1			1		3

economic risk mitigation	**1**	**1**					**1**	**1**			**4**
Invest							1	1			2
Resource	1	1									2
new concept						**1**					**1**
Power						1					1
operational issues			**1**	**2**		**1**	**1**	**1**			**6**
Environmental				1				1			2
Exploitation			1	1		1	1				4
sub-surface knowledge		**1**	**1**	**1**		**1**		**1**			**5**
Data		1	1	1		1		1			5
structuring geothermal sector	**1**				**2**	**1**	**1**				**5**
Market					2		1				3
coordination capacity	1					1					2
public acceptance	**1**	**1**	**1**			**3**	**1**	**1**			**8**
environmental issues	1	1	1			2	1				6
Dissemination						1		1			2
visibility and dissemination		**1**	**1**				**1**	**2**		**3**	**8**
R&D										3	3
Dissemination		1	1				1	1			4
geothermal policy								1			1
education and training						**1**					**1**

	CH	Germany	France	Hungary	Iceland	Italy	NL	Slovenia	Slovakia	Turkey	Total
Education						1					1
Total	**5**	**6**	**5**	**6**	**2**	**12**	**6**	**7**	**4**	**3**	**56**

Table 15: (Table A.2 Opportunities) Clusters and sub clusters by number of issues

	CH	Germany	France	Hungary	Iceland	Italy	NL	Slovenia	Slovakia	Turkey	Total
Regulation					**3**	**2**	**1**				**6**
administrative issues						1					1
Commitment						1					1
specification & standardization					3		1				4
Economic			**2**			**2**					**4**
Policy						1					1
project life time			1								1
risk mitigation			1			1					2
new concepts		**1**	**2**		**4**	**4**	**4**	**1**		**4**	**20**
info exchange							1				1
Market					1						1
Demo		1	1		1						3
integrated/holistic view			1		2	3	2				8
optimized/innovative technology						1	1	1		4	7
operational issue							**1**	**2**		**1**	**4**

operational issue							1	2		1	4
sub-surface knowledge	**1**	**1**		**1**		**2**					**5**
sub-surface knowledge	1	1		1		2					5
structuring geothermal sector	**2**		**1**			**2**					**5**
structuring geothermal sector	2		1			2					5
public acceptance						**1**			**2**		**3**
public acceptance						1			2		3
Visibility							**1**		**1**		**2**
Visibility							1		1		2
education and training		**1**									**1**
education and training		1									1
Total	**3**	**3**	**5**	**1**	**7**	**13**	**7**	**3**	**3**	**5**	**50**

Importance and Urgency

Also, we prepared an overview of importance and urgency of the issues mentioned. The "titles" of the issues were sometimes a bit abbreviated for conciseness, or to facilitate analysis. The issues are now in an alphabetic order. The numbering in the left column is consistent with the numbering in the main report. Very urgent/important issues have a `2´, other issues a `1´.

Issues which are considered both of high importance and of high urgency are marked in red.

Table A.3: Barriers: Importance and urgency

		Urgency	Importance
CH	**Switzerland**		
5	Asset ownership, rules and regulations	2	2
3	High cost of subsurface development	2	2
2	Induced seismicity – maintaining the social licence-to-operate	2	2
4	Low capacity of industrial sector to build, own and operate deep geothermal energy facilities	1	2
1	Low POS finding hydrothermal resources	2	2
DE	**Germany**		
2	Approval procedure	2	1
6	Costs	1	2
4	Exploration	1	1
1	Lack of public acceptance	2	2
3	Prospecting risk	2	2
5	Significance	1	2
FR	**France**		
3	Environmental aspects and public acceptance	1	1
5	Inadequate incentive framework	1	1
4	Lack of knowledge about geothermal energy	1	1
2	Resource exploitation	1	1
1	Resource exploration and dissemination of the related data	1	1
HU	**Hungary**		

6	Banning on hydrofracking	1	1
5	Diverse and unharmonized databases	2	1
1	Diverse legislation	2	1
3	Lack of financial incentives	2	2
2	Multiple licensing	2	1
4	Re-injection into porous aquifers	1	1
IS	**Iceland**		
2	District heating market is saturated	1	2
1	Low electricity prices and isolated grid	1	2
IT	**Italy**		
3	Administrative issues for H&C and direct uses	1	2
2	Administrative issues for power production	2	2
11	Costs for resource exploitation	2	2
4	Data access	2	1
13	Education and training	2	2
12	Feed-in-tariff and support policies	2	2
10	Induced seismicity issues	1	1
14	Operational issues	2	2
8	Pollution	1	1
6	Social acceptance and communication strategy	1	2
5	Stakeholder fragmentation and self-referentiality	2	2
9	Technology	2	2
NL	**Netherlands**		
1	Financing & up-front subsidies	2	2
4	Geochemistry & injectivity – (operational problems)	2	2
5	Insufficiently developed business chain	1	1
3	Knowledge transfer	2	2
2	Risk mitigation	2	2
6	Threat of changes in public opinion on geothermal energy	1	1
SI	**Slovenia**		
4	Environmental impact	1	2
3	Geothermal energy evidence	1	1
1	Geothermal policy	2	2

2	Incentives and risk insurance	2	1
11	Lack of geophysical data and deep structural boreholes	1	2
5	Licensing	1	1
6	Promotion	2	1
SK	**Slovakia**		
1	Feed in tariff reduction	2	2
2	Geological and water act mismatch	1	1
3	Insufficient protection of geothermal wells and constructions	1	2
4	No support from Operational Program Environment for new geothermal wells	2	1
TR	**Turkey**		
1	Management of joint R&D projects with foreign partners	2	2
3	Presenting R&D projects of geothermal energy	1	1
2	University- Industry collaboration in relevant R&D areas	1	1

Table 16: (Table A.4) Opportunities: Importance and urgency

		Importance	Urgency
CH	**Switzerland**		
6	Developing indigenous natural resources	2	1
7	Security of supply	2	1
8	Strengthening Switzerland's role as a research and technology hub; creation of jobs	2	1
DE	**Germany**		
8	Consolidate information/data	2	2
7	Enhance knowledge on geothermal energy	1	1
9	Promote the advantages of GT with a "lighthouse"-project	2	2
FR	**France**		
9	A very long lifetime that balances the significant investment costs	1	1
8	Developing various uses of geothermal heat	1	1
7	Enlarging the exploited geothermal resources; New concepts for geothermal energy	1	1
10	Risk mitigation schemes for power projects	2	1

6	Structuring the geothermal sector	2	1
HU	**Hungary**		
7	Concession	1	1
IS	**Iceland**		
4	Bio technics	1	1
5	Chemical industries connected to geothermal gas exhaust.	1	1
8	Geothermal datasets specification	2	2
7	Geothermal energy statistics	2	2
3	Horticulture and fish farming	1	1
6	Living lab for geothermal research and utilisation.	1	1
9	Metadata cataloguing of geothermal datasets	2	2
IT	**Italy**		
18	Administrative issues	2	2
27	Employment	2	2
23	Exploitation of the off-shore sources	1	1
16	Feed-in-tariff and support policies	2	2
21	Geothermal Databases	2	2
25	Increase of geothermal energy production	2	2
15	Mining risk insurance	2	2
17	Multi-source systems for heat production	1	2
24	National technological production and supply chain	2	1
20	New technology development for power production	2	2
26	Resource assessment	1	2
19	Social acceptance and communication	2	2
22	Well recovery for natural gas extraction	1	1
NL	**Netherlands**		
7	Better visibility of geothermal energy in national RD&D programmes	1	2
9	Broadening the knowledge base – international, related technologies	1	2
12	Innovative applications	1	2
13	Innovative concepts		
11	Innovative drilling and operation technologies, incl. load management	1	2
8	Organising the knowledge base incl. sharing operational knowledge.	1	2
10	Standardising procedures, incl. exploration permits	1	2

SI	**Slovenia**		
9	Best available technology	1	1
10	Reinjection	2	2
8	Thermal efficiency	1	1
SK	**Slovakia**		
5	Localities with suitable conditions for geothermal energy utilization	2	1
6	Reduction of carbon footprint	1	1
7	Reduction of deforestation of the country	1	1
TR	**Turkey**		
6	Heat Pumps	1	1
7	Power distribution and transmission	1	1
4	Renewable heating and cooling	1	1
5	Underground storing	2	2

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