The role of public authorities in supporting financially geothermal

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ABSTRACT

This paper aims to highlight the main financial barriers to, and the needs for the development of geothermal technologies, and to propose innovative and differentiated tools for funding both geothermal heat and geothermal electricity. To this end, this document will put forward key recommendations for designing new and improving the functioning of existing public support schemes:

- Support schemes are crucial tools of public policy for geothermal to compensate for market failures and to allow the technology to progress along its learning curve. By definition, they are temporary and shall be phased out as this technology reaches full competitiveness;

- Market failures and unfair competition prevent full competition in the electricity and heat markets, while the current capital crunch obstructs the necessary private financing mobilisation to realise the enormous geothermal potential;

- Geothermal technologies hold significant potential for cost reduction. Dedicated support schemes should allow to reduce costs;

- Innovative financing mechanisms should be adapted to the specificities of geothermal technologies and according to the level of maturity of markets and technologies;

- Geothermal Risk Insurance Fund (GRIF) is seen as an appealing public support measure for overcoming the geological risk. As costs decrease and markets develop, the private sector will be able to manage project risks with, for example, private insurance schemes, and attract private funding;

- While designing a support scheme, policy-makers should take a holistic approach, which goes beyond the LCoE and includes system costs and all externalities. As an alternative, there is the chance to offer a bonus to geothermal for the benefits it provide to the overall electricity system: flexibility and base-load;

- Geothermal heat technologies are heading for competitiveness, but support is still needed in certain cases, notably in emerging markets and where a level-playing field does not exist.

- Given the level of maturity of innovative geothermal technologies and the negligible support received so far, it seems premature to talk about the need for more market-based mechanisms or even phase-out financial support for geothermal.

1. INTRODUCTION

This paper aims to highlight the main financial barriers to, and the needs for, the development of geothermal technologies. It explores innovative and differentiated tools for funding both geothermal heat - which has received less attention to date - and geothermal electricity. To this end, this document puts forward key recommendations for designing new and improving the functioning of existing public support schemes.

1.1 Why Should Public Funds be Used to Support the Geothermal Industry and Interfere with the Market?

The primary objective of financial incentive schemes is to compensate for market failures and unfair competition. They are also intended to favour the deployment of a given technology by creating a secure investment environment catalysing an initial round of investment and thereby allowing the technology to progress along its learning curve. Hence, support schemes should be temporary and can be phased out as this technology reaches full competitiveness in a (then) complete and open internal market where a level playing field is fully established.

Today, however, market conditions in the EU electricity and heat sectors prevent geothermal from fully competing with conventional technologies developed historically under protected, monopolistic market structures where costs reduction and risks were borne by consumers rather than by plant suppliers and operators. The internal market is still far from being perfect and transparent. Firstly, in many countries electricity and gas prices are regulated, thus they do not reflect the full costs of the electricity and/or heat generation. Secondly, fossil fuel and nuclear sectors still receive many subsidies. Thirdly, there is lack of market transparency, including lack of information provision to customers and tax-payers and a clear billing.

Support measures for geothermal technologies are therefore needed to favour the progress towards cost-competitiveness of a key source in the future European energy mix and to compensate for current market-failures.

1.2 Investment Climate

Public support for geothermal energy should help mobilising private financing in a difficult investment climate. The economic and financial crisis has indeed affected investment in clean energy. The period 2012-2015 saw a decline in investment in Europe but the situation country by country is very different. For instance, whilst some countries such as Germany have maintained their level of financing, elsewhere financing geothermal projects has become more difficult.

The picture appears already to be complicated, and it should be added that Geothermal is a capital intensive technology that takes some years to develop. The significant initial investment is related to the drilling and to the need to cover the geological risk at the beginning of the exploration. This is valid for all deep geothermal projects as well as for open shallow systems. Such a barrier can be tricky to overcome, especially with the European stock markets still uncertain and with banks exclusively looking for zero risk.

1.3 Mitigating the Risk

With the notable exception of a few European market participants operating in well-developed geothermal regions, project developers have very little capability to manage the financial risk owing to the poor knowledge of the deep subsurface, lack of technological progress and high cost. In effect the probability of success/failure weighted net present values of project cash flows tend to be overly negative, thus effectively shutting out private capital from investing in geothermal energy.

However, with technology development (increasing the probability of success of finding and developing geothermal reserves) coupled with experience and thus reductions in cost, project developers will eventually be able to accept and, where appropriate, transfer project risks (technical, economical, commercial, organisational and political) in such manner that private funding will become available. Until then, a Geothermal Risk Insurance Fund (GRIF) is seen as an appealing public support measure for geothermal.

1.4 A System-Approach: the Benefits of Developing Geothermal

The European Commission plans to prepare guidance on best practice and experience gained in support schemes for renewables and, if needed, on support scheme reform. However, the current debate only focuses on the levelised costs of the electricity technologies without assessing their overall impact on the market, including with regard to the need of additional infrastructure and required costs for back up.

In analysing the impact of geothermal energy deployment it should be pointed out that:

- Geothermal provides renewable base load and flexible generation of electricity and continuous heat/cold production everywhere in Europe;
- the initial upfront costs are followed by very low operational costs (as the fuel, i.e. geothermal water/steam is free of charge) and high production revenues as, for instance in electricity, geothermal presents the highest capacity factor of all electricity technologies (about 90%);
- from a system-approach perspective, a marginal, additional, geothermal plant, does not add any extra cost in terms of back up requirement and transmission and distribution infrastructure;
- it can therefore alleviate the need for additional infrastructure and genuinely increase the security of energy supply at regional, national and European level;
- it can produce electricity and heat, also in a cascade approach;
- it is friendly to the environment and contributes to the reduction of GHG emissions.

1.5 Going beyond the “One-Size-Fits-All Approach”: the problem of technology neutrality.

The development of geothermal energy is driven by a number of interacting factors and the relationship between market and policy can be critical. For instance, electricity can be produced from geothermal resources through many different processes, and with varying efficiency. Geothermal technologies recently demonstrated such as EGS, will become competitive in a near future.

However, policy recognition of all these differences and variations is somewhat lacking, resulting in the design of generalised incentives which do not reflect the large variety in the scale of technology, final utilisation, or degree of maturity. This means that in the end, the incentives may fail to provide any real benefit for geothermal actors. Therefore, a different approach is needed so as to tailor the market and policy environment to a suitable model which optimises the development of geothermal resources.

The discussion on the liberalisation of the power sector has at times attributed market distortions almost exclusively to the regulatory frameworks for the promotion of renewable energy. However, as the European Commission states in the Staff Working Document (2013) 439, market failures are systemic and long-standing and support mechanisms have been enacted to counter these persistent market flaws.

The State aid guidelines 2014-2020 aim to minimise market distortions allegedly caused by the financial support to renewable energy. To that end, they indicate an evolution towards technology neutral support mechanisms from 2017 onwards. Although the Guidelines provide some flexibility for their application through exemptions for small-scale plants and through opt-out provisions, they fail to fully take into consideration the specificities of the power sector and the intrinsic characteristics of renewables.

A technology neutral, market-based approach to energy systems will fail to deliver on the EU's climate and energy objectives. A one-size-fits-all model will favour incumbent technologies and undermine energy security by hampering the deployment of indigenous renewable sources. Moreover, it will prevent timely investment decisions necessary for the decarbonisation of the power system and add additional costs to the energy transition.

No single support model can properly factor in the different technology profiles of renewable energy sources. Applying a single system across the board stifles innovation and slows technology cost decrease. Technology neutral systems require technologies with significantly different technical characteristics to compete instead of incentivising the deployment of a broad mix of renewables that can make the energy system more efficient and more resilient.

Support mechanisms need to be differentiated according to the technical characteristics of each technology (e.g. cost, size, risk profile, project lead time, ability to provide system services). This would ensure the most cost effective deployment of a sufficiently broad portfolio of renewable energies to meet the EU's renewables targets for 2020 and 2030 and drive the long-term decarbonisation objective of the EU economy.

2. GEOTHERMAL TECHNOLOGIES AND COSTS

2.1 Geothermal Electricity

Over the last 100 years, the production of geothermal energy has been concentrated in areas where rich hydrothermal resources are available. However, the development of advanced technologies has enabled the production of geothermal energy at low temperature in all European countries. Today, three technologies exist to produce electricity from geothermal energy and one is under development:

1) Conventional high temperature, hydrothermal geothermal electricity production (dry steam and flash steam)

As demonstrated in numerous sites since 1904, heat from the underground can be converted into electricity with dry steam power plants and flash steam plants (water dominated reservoirs and temperatures above 180°C).

2) Low temperature, hydrothermal geothermal electricity production (Binary: ORC and Kalina Cycle)

Binary, known also as organic Rankine cycle (ORC) or Kalina Cycle, plants operate usually with waters in the 100 to 180°C temperature range. Adequate working fluid selection may allow extending the former design temperature range from 180°C to 75°C.

3) Enhanced Geothermal Systems – EGS, geothermal electricity production

An Enhanced Geothermal System is an underground reservoir that has been created or improved artificially. The concept of Enhanced Geothermal Systems is going greatly increase geothermal potential as it allows for the production of geothermal electricity nearly anywhere in Europe with medium and low temperature. This concept involves:

- Using the natural fracture systems in the basement rocks
- Enlarging its permeability through massive stimulation
- Installing a multi-well system
- Through pumping and lifting, forcing the water to migrate through the fracture system of enhanced permeability ("reservoir") and use the heat for power production

A major effort to introduce EGS could create a substantial base-load electric power production, as geothermal energy is available independent from the time of day or year, of climate, weather, etc. A steady increase in geothermal power production could be expected in all EU countries.

4) Supercritical fluids

The long-term evolution for geothermal resource exploitation concerns the supercritical zones of geothermal fields with very high temperatures (up to 500°C) at relatively shallow (< 5 km) depths. It is expected that supercritical fluid can provide 5-10 times more energy per volumetric flow compared to conventional geothermal power plants using condensing turbines. Thus it will have a tremendous effect on the production capacity of geothermal energy.

2.2 Geothermal Heating and Cooling

With geothermal energy for heating and cooling, two main resource types are distinguished:

1) The first (very low temperature in the range of the annual mean air temperature on site, up to about 25 °C) is based on the stable groundwater and ground temperatures at shallow depth (the limit is typically set at 400 m). Typically, heat pumps are used to extract energy from the ground and raise the temperature to the level required by the heating systems.

2) The second (low and medium temperature, ranging from 25 °C to over 100 °C) extracts the heat from ground and groundwater at higher temperature, and typically at greater depth. If the geothermal heat is at a level of temperature compatible with the temperature required by the heating system, the energy from the ground or the ground water can be used directly (without any thermodynamic device). Direct applications are found in:

- district heating or combined heat and power installations
- agriculture (horticulture, aquaculture, drying)
- industrial processes
- balneology
- absorption heat pumps for cooling purposes

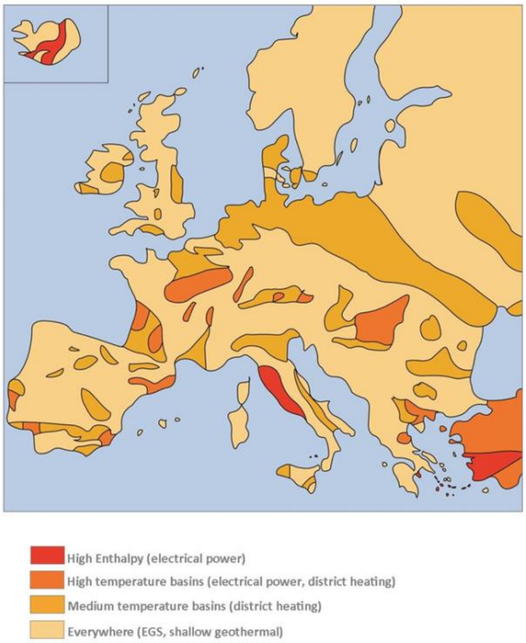


Figure 1: Geothermal resources in Europe.

2.3 Economics of Geothermal Technologies

Where high-temperature hydrothermal resources are available, in many cases geothermal electricity is competitive with newly built conventional power plants

Binary systems can also achieve reasonable and competitive costs in several cases, but costs vary considerably depending on the size of the plant, the temperature level of the resource and the geographic location, whilst EGS cost cannot yet be assessed accurately because of the limited experience derived from pilot plants.

Geothermal heat may be competitive for district heating where a resource with sufficiently high temperatures is available and an adaptable district heating system is in place. Geothermal heat may also be competitive for industrial and agriculture applications (greenhouses).

Regarding Geothermal Heat Pump technology, it can be considered mature and competitive, but only a level playing field with the fossil fuel heating systems will allow phasing out any subsidies for shallow geothermal in the heating sector.

All in all, geothermal electricity and heat can be competitive under certain conditions, though R&D and enabling polices are still necessary to reduce the levelised cost of energy of less conventional geothermal technology.

LCo of Geothermal Electricity	Costs 2012 Range(€/kWh) (€/kWh)	Average	Costs 2030 Average (€/kWh)
Electricity Conventional – high T°	0,05 to 0,09	0,07	0,03
Low temperature and small high T° plants	0,10 to 0,20	0,15	0,07
Enhanced Geothermal Systems	0,20 to 0,30	0,25	0,07
LCo of Geothermal Heat	**Costs 2012 Range(€/kWh) (€/kWh)**	**Average**	**Costs 2030 Average (€/kWh)**
Geothermal DH	0,02 to 0,20	0,06	0,04
Geothermal direct uses	0,04 to 0,10	0,05	0,04

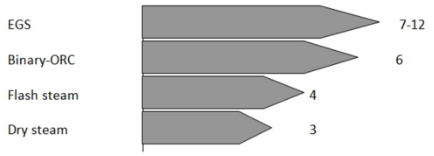
Figure 2: Levelised costs of geothermal technologies.

2.3.1 Technology Costs

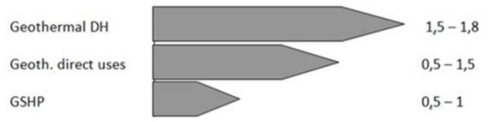
Investment costs: Geothermal electricity development costs vary considerably as they depend on a wide range of conditions, including resource temperature and pressure, reservoir depth, location, drilling market etc. See below the capital costs per geothermal technology.

Operation and Maintenance costs: O&M costs in geothermal electricity plants are limited, as geothermal plants require few or no fuel.

Commercial costs: Commercial costs associated with developments also need to be included in costing a geothermal project. These include financing charges (including establishment costs and interest), interest during construction, corporate overhead, legal costs, insurances. For geothermal, risk insurance is the main issue. It depends on the origin of the resources invested and the way they are secured, as well the amount of initial capital investment.



Capital costs, € million /MWe installed



Capital costs, € million /MWth installed

Figure 3: Capital costs of geothermal technologies.

2.3.2 Production Costs

LCoE: Levelised generation costs of geothermal power plants vary widely. New plant generation costs in some countries (e.g. Tuscany-Italy) are highly competitive (even without subsidies) at ca. € 50/MWh for known high-temperature resources. They are largely depending on the main cost components: drilling which can be 30% for high-temperature plants 50% for low temperature and 70% for EGS. The very high capacity factor >90% (the highest of all energy technologies including nuclear) mitigates the capital intensity to render geothermal technologies competitive.

System costs: The geothermal power plant is assumed to be located in the vicinity of the national transmission network, so systems costs are very low. A reliable arrangement for the interconnection of a power plant to an existing transmission line is through the deviation of the transmission line into the power plant switchyard. Given the cost estimation of a 1 MWe power plant, the transfer station will cost about €80,000 to €85,000. In contrast to this, the costs for routing and cable installation are strongly related to the grid connection point assigned by the grid operator and therefore have site specific costs. Depending on the cable's diameter, a price of €100-150 per meter is quite common. Geothermal energy is a local renewable energy, producing 24h a day, everywhere; i.e. a local energy source with limited network needs. Externalities: Geothermal has received very little R&D funding in comparison with other RES and conventional technologies. Moreover, geothermal is a renewable energy with very low GHG emissions so external costs of pollution damage are negligible

Business impact: Geothermal is affected like all other sources of energy by future change in legislation, but is immune from fuel price volatility.

3. FINANCIAL BARRIERS & NEEDS

In the foregoing section, we have seen that some conventional geothermal technologies have been competitive on the market for decades. However, with more innovative technologies progressing along their learning curve, large private investments are needed in order to enable the development of geothermal energy everywhere in Europe. In this regard, the role of EU and national policy-makers in setting the most favourable climate for investments is crucial. This means that a number of specific barriers need to be removed so as to involve new developers and groups of investors.

The main financial factors that can prevent geothermal from developing further are summarised below:

- Geothermal energy projects, particularly those where technological progress, experience curves and hence cost reductions are required to reach commercial viability, do not have access to private funds for financing;

- There is poor knowledge of the deep subsurface over large parts of Europe;

- Geothermal is a capital intensive technology that takes some years to develop. The significant initial investment is related to the drilling and to the need to cover the geological risk at the beginning of the exploration;

- The homogeneity of products derived from geothermal energy (e.g. power, heat, tradable emission reduction certificates) do not command a premium that can be levied nor enable the development of niche products;

3.1 Geothermal Project Financing

Capital costs for geothermal generation per MWe range between EUR 4 and 7 million. They are higher than all other renewables and conventional technologies and highly dependent upon the specific site and technology.

Capital costs are also dependent on drilling, namely:

- the number of geothermal wells required

- the depth of drilling

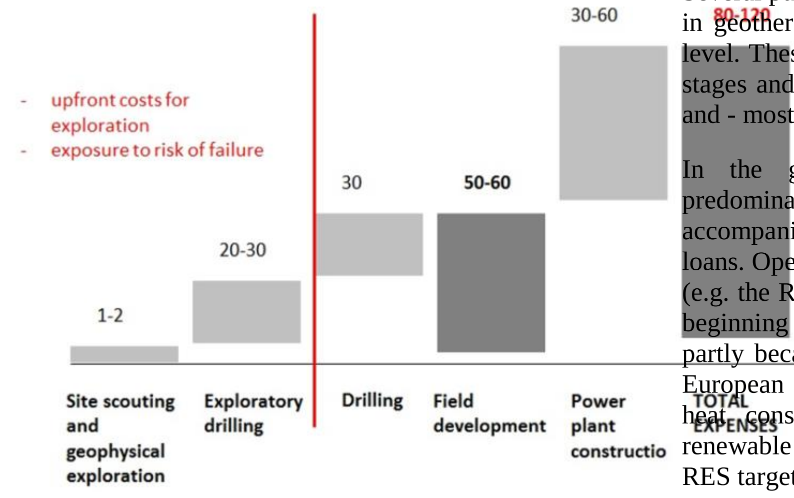


Figure 4: Example: € million, based on a 20 MWe conventional high temperature plant.

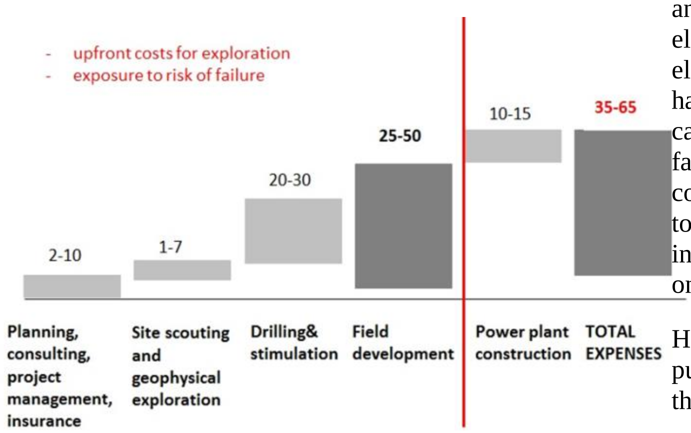


Figure 5: Example: € million, based on a 5 MWe EGS plant.

In addition geothermal is associated with the geological risk. The geological risk exists especially at sites with only partially known subsurface conditions: the geothermal resource could be below expectations the fluid could be insufficient.

Geothermal district heating projects face the same issues as geothermal power plants. The two points described above (need of capital and risk mitigation) are therefore also valid for this technology. Moreover, notably because of the drilling, geothermal heat pumps can also be considered as a capital intensive technology in comparison with other small scale applications.

It should be added that an important barrier for both electricity and heating and cooling sectors is the unfair competition with gas, coal, nuclear and oil, which is the primary reason justifying the establishment of financial support schemes for geothermal.

3.2 Mechanism for Funding

As mentioned above, geothermal project development has high upfront costs that can take 3-6 years.

Several public mechanisms for supporting investments in geothermal energy exist at European and national level. These mechanisms can address different project stages and can include R&D funding, investment aid, and - mostly for geothermal electricity- operating aid.

In the geothermal heating sector, there is a predominance of investment grants, in certain cases accompanied with or substituted with zero interest loans. Operational aid similar to a feed-in tariff system (e.g. the Renewable Heat Incentive in the UK) is now beginning to be explored in some Member States, partly because of the inclusion of the sector into the European regulatory framework (21.4% of the final heat consumption in the EU should come from renewable sources, in order to achieve the overall 20% RES target.

Regarding geothermal electricity, the main support instrument in the EU is the feed-in tariff, i.e. a fixed and guaranteed price paid to the eligible producers of electricity. By increasing the competitiveness of electricity produced from renewables, feed in tariffs have a positive effect on the ease with which investors can obtain financing for their projects. As a matter of fact, the costs of capital for investments observed in countries with established tariff systems have proven to be significantly lower than in countries with other instruments that involve higher risks for future returns on investments (ECOFYS et al, 2011)

However, it is worth highlighting here that stable public support in favour of geothermal is at stake for the following reasons:

1) National budget constraints following the financial and economic crisis;

2) The success of other renewable technologies has led to a more market-oriented approach towards support schemes for renewables.

Indeed, the geothermal sector risks being victim of the measures put in place to limit the growth of photovoltaic and on-shore wind, for which substantial support, often overcompensating their real cost and bringing about windfall profits, has led to a reduction costs.

The new EU guidelines on state aid for environmental protection and energy 2014 – 2020 impose the following standard rule as of 2016: Member States can grant public support only by means of technology-neutral auctioning and feed-in premiums, with renewables operators, directly marketing their electricity in the market.

In this framework it seems that the auctioning system is the most problematic element of the reform. However, upon request of national governments, some exemptions to this standard rule are still possible. It is therefore important to point out to the national governments that only a handful of geothermal projects have received operational aid over the last years, and that, considering the current levels of maturity of binary-cycle and Enhanced Geothermal Systems technologies and their deployment speed, it seems therefore premature to talk about the need for more market-based mechanisms or even phase-out financial support for geothermal electricity.

4. RECOMMENDATIONS FOR FINANCING MECHANISMS FOR GEOTHERMAL

4.1 Recommendations for Support Schemes

1) A balanced approach among RES technologies is required because, as we have seen in Chapters 2 and 3, they do not have the same maturity, same capacity factor (base load, flexible, variable) and same attention or level of support.

2) Support schemes must be predictable in the long term to encourage investments (No stop & go policy – see for instance the Moratorium in Spain);

3) Growth corridors instead of caps must be established (risk of stop-and-go in the market)

4) No retroactive cuts should be allowed;

5) These schemes have to be simple and transparent in design and implementation, implying low administrative burden and costs (well-designed they are cost efficient) ;

6) The base-load and the flexible characters of geothermal and its contribute to electricity grid stability should be rewarded;

7) Public support schemes should cover different financial needs: R&D, demonstration, exploration phase to identify areas of interest, drilling/production phase (market conditions);

8) The regional and local benefits should be taken into account;

9) A regular digression of tariffs is set to allow technology improvements and cost reductions;

10) The instruments and incentives to bring favourable conditions for geothermal development are the following:

- Grants, guarantees, directs or convertibles
- Feed-in Tariff & Feed-in Premium
- geological risk coverage with risk insurance schemes: public exploration to identify best areas, R&D support, geological database are flanking measures to lower the geological risk.
- R&D support
- Additional measures like portfolio standards, tax credits, public support (EU, governmental, local)

4.2 Towards adapted Geothermal Risk Insurance Fund (GRIF)

Rationale of the GRIF

For now, the fairly small number of geothermal electricity operations in the EU does not provide a sufficient statistical basis to assess the probability of success. As a consequence, geothermal developers struggle to find insurance (public or private) schemes with affordable terms and conditions for the resource risk. In those circumstances, the GRIF aims at alleviating the shortage of insurance policies for the resource risk and ease investments in geothermal electricity projects.

Principles of the GRIF

The GRIF is meant to work through the pooling of the resource risk among geothermal electricity projects taking place in the EU. The GRIF should be first supported by public money; when mature this could be phased out and replaced by private schemes.

Background

The guarantee should cover the cost of a well in case of partial or total failure (partial up to 90 % compensation). It would be financed by Public/Private Funds and subscriptions from project developers. The insurance will cover risk in the short and long term. The main criteria for the level of risk will be a combined ratio including the flow rate and the temperature.

The detailed of the GRIF can be found in the Geoelec report.

Case study: Poland

When looking at the deep geothermal market in this country, one could notice that two geothermal power plants are in under investigation, six geothermal district heating systems are currently in operation and five geoDH projects are under development (Extension existing networks). Several other direct uses with deep geothermal are also in operation in Poland. We can estimated that around twenty wells have been drilled and 15 to 20 will be drilled by 2020.

So although the market is ancient and that a national expertise exists, with less than ten projects in operation and less than ten under development, the polish market can still be considered in its juvenile phase.

The objective would then be to guarantee the cost of a well in case of partial or total failure. Firstly for such a juvenile market, (Convertible) Grants for seismic exploration, slimholes, and the 1st well are the most adequate support schemes. Subsequently when more wells have been drilled and dozen of deep geothermal projects are in operatiuon, so for intermediate market, a public risk insurance is then seen as the most appropriate tool. It should be the case of Poland by 2020 or just after that date. Indeed, then the geology would be better known, more projects would be developed and be able to mutualise the risk all together, more financial institutions should be attracted. The geological risk should be easier to mitigate and more economical.

The governance of such a public national financial tool is shared between the Ministry, National Energy Agency, Geological Survey and a committee of experts. A State budget of 40-60 Mio € could help to launch this fund in Poland. This amount would indeed allow to cover the next 6-10 wells (3-4 deep geothermal systems), with a premium of 6-7% of the maximum guaranteed amount. It is a mutual insurance in order to develop projects in favorable regions and to have operations in new areas.

The ultimate stage is when the market is considered enough mature to see private insurers proposing risk insurance at a competitive price.

Risk insurance funds for geothermal already exist in France, Switzerland and the Netherlands in the past also in Iceland).

4.3 Towards adapted support schemes to operation and investment

If risk insurance is recognised to be a prerequisite for developing deep geothermal projects, financial subsidies for investment and operational support are also crucial. As explained in the introductory chapter, they help the technology to decrease its costs and compensate for market failures.

But it appears clear the also these financial incentive schemes must be designed according to the market maturity of the sector (figure 6 below):

- Investment aid is seen more appropriate for juvenile markets
- Feed-in tariff would fit for intermediate market
- And Hybrid support schemes (feed-in premium) for pre-commercial technologies in a near mature market
- When market is mature and with a fair competition, this market will reward geothermal for its value (base load, flexible, participating to the local development with multi-purpose systems)

Today new geothermal projects in operation benefit of fixed and guaranteed tariffs for each kilowatt-hour produced. However, the progressive market integration of renewable generators (direct sale of electricity in the market and feed-in premiums granted through competitive bidding) and the underlying uncertainty in terms of revenues makes the financing of geothermal projects more challenging, notably in energy-only markets.

A possible source of revenue is from ancillary services that geothermal operators can offer to transmission and distribution system operators from balancing markets. In this regard, however, it is critical to assess whether current market designs sufficiently reward the economic value of the short and long-term flexibility from renewable flexible technologies or whether they need to be deeply reformed.

3. CONCLUSIONS

Accelerated deployment of geothermal energy will require investments that cannot solely rely on public funds. Hence, the engagement of the private sector is crucial. However, financial barriers to develop geothermal power projects in Europe still persist and need to be overcome through the public support at the beginning of geothermal development. An ideal scheme would be for public authorities to finance the exploratory and preferably also the pre-feasibility phases of geothermal development; investors would take over.

Another crucial element for geothermal development concerns the establishment of a risk insurance system. A priority should be to create this scheme, with a risk guarantee for failures of the drilling operations and the exploitation phase.

In addition, the persistence of market failures such as regulated prices in a non-completed EU energy market and the fact that negative externalities and security of energy supply are not yet fully internalised into energy prices, leave geothermal energy and other renewables at a competitive disadvantage compared to conventional energy sources. Hence, support schemes, notably financial support mechanisms such as feed-in tariffs, are intended to temporary compensate for the various market failures still existing today.

Policy makers need to set the type and level of support according to the maturity of the technology and of the market. Therefore, the feed-in tariff still appears to be the most appropriate mechanism to stimulate the market uptake of innovative technologies such as low temperature and EGS technologies. As a matter of fact, by increasing the competitiveness of electricity produced, feed in tariffs should have a positive effect on the ease with which investors can obtain financing for their projects. In the longer term, after new geothermal technologies have made significant progress along their learning curve, the optional mechanism of a feed-in premium, consisting of allowances granted in form of a bonus paid on top of the electricity market price can be also made available.

Regardless of any eventual black swan, in the next years the cost of fossil fuels is expected to rise. At the same time, ensuring competitiveness and access to affordable energy for all is crucial, notably in difficult economic times. In this respect, geothermal energy can not only contribute to a decreasing in energy system costs (as it does not require additional system costs), but improve security of supply (it is available everywhere, 24 hours a day), and can boost local economies, empowering consumers and improve urban environment conditions (as it is local, sizeable and close to demand centres).

Geothermal energy will be key source in the European energy mix. In order to realise its full potential to the benefit of European economies and citizens alike, it needs increased and dedicated support now!

Market Maturity	**Juvenile**	**Intermediate**	**Mature**	**Post 2020**
Criteria	0-12 to 15 deep geothermal wells are existing < than 3 plants are operational	12-60 deep geothermal wells exist < than 10 plants are operational	Both geoelec & geoDH systems are developed all over the country	Costs reach grid parity with around 10 €ct/kWh
Level of risk	Very high	high	medium	Low
Costs: **High temperature** **Low temperature and small high T° plants** **EGS**	na 18 30	7 16 25	6 15 23	5 10 12
Support schemes to operation and investment	Feed-in tariff / investment aid	Feed-in tariff / investment aid	Hybrid support schemes	Markets rewarding flexibility
	(Convertible) Grants/guarantees for seismic exploration, slimholes, and the 1st well	Public Risk insurance	Public & private Risk insurance	Private Risk insurance

Figure 6: Towards adapted support schemes to operation and investment.

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