EUROPEAN GEOTHERMAL ENERGY COUNCIL

Financing Geothermal Energy

July 2013

EGEC Policy Paper

EGEC, the European Geothermal Energy Council, was founded in 1998 as an international non-profit association in Brussels, with the aim of promoting the use of geothermal energy in Europe.

EGEC has 128 members from 28 European countries: private companies, national associations, consultants, research centres, geological surveys and other public authorities.

Financing Geothermal Energy

Contents

Key Messages

- 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. This document details specific aspects and recommendations on how to reduce costs;

- Innovative financing mechanisms (Figure 14) should be adapted to the specificities of geothermal technologies and according to the level of maturity of markets and technologies;

- A *European Geothermal Risk Insurance Fund* (EGRIF) 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. In addition, there is a need for an in-depth analysis of the heat sector, including about the best practises to promote geothermal heat, the synergies between energy efficiency and renewable heating and cooling, and barriers to competition.

- 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.

Introduction

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 - 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.

Why public funds should 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.

Geothermal jobs creation:

Geothermal directly employs already about 40.000 people, including manufacturing, distribution, installation, and O&M. Building on the geothermal targets in the National Renewable Energy Action Plans, it is assumed that in 2020 direct jobs in the geothermal sector will double to ca. 80.000 direct jobs.

As geothermal technologies are site specific (geology is different all over Europe) and capital-intensive, it is expected that the jobs created will remain local and cannot be exported, e.g. to China.

The sector will move from a geological approach to an engineering approach where systems can be replicated but can hardly be industrialised. It is estimated that 85% of the geothermal value chain in Europe is local and it is planned to remain as such.

Because of the nature of the work, we can assume that construction and O&M cannot be relocated, meaning that they are “European” jobs. Regarding equipment (rigs, turbines), the number of large manufacturers is not forecast to boom internationally.

Investment climate

Public support for geothermal energy is that it is meant to mobilise private financing in a difficult investment climate. The economic and financial crisis has indeed affected investment in clean energy. 2012 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.

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 *European Geothermal Risk Insurance Fund* (EGRIF) is seen as an appealing public support measure for geothermal.

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 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.

Going beyond the "one-size-fits-all approach"

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 structure of this paper

Chapter 1 of this EGEC policy paper on financing geothermal spans the range of existing geothermal technologies for electricity and heating and cooling and analyses their economics, including with regard to capital and commercial costs.	*Chapter 3* looks at the most common mechanisms for supporting geothermal energy at EU and national level and includes an analysis of the EU R&D funds allocated over the last 10 years.
Chapter 2 is an overview of the several phases of a geothermal project. This chapter also presents the financial barriers as well as the main tools needed in each of these phases.	*Chapter 4* analyses the potential costs reduction of geothermal technologies and, based on this, puts forward recommendations on how to adapt existing support schemes and introduces what can be the innovative financial tools required to overcome the most serious barriers to the development of geothermal energy in Europe.

1. Geothermal technologies and costs

1.1 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.

1.2 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

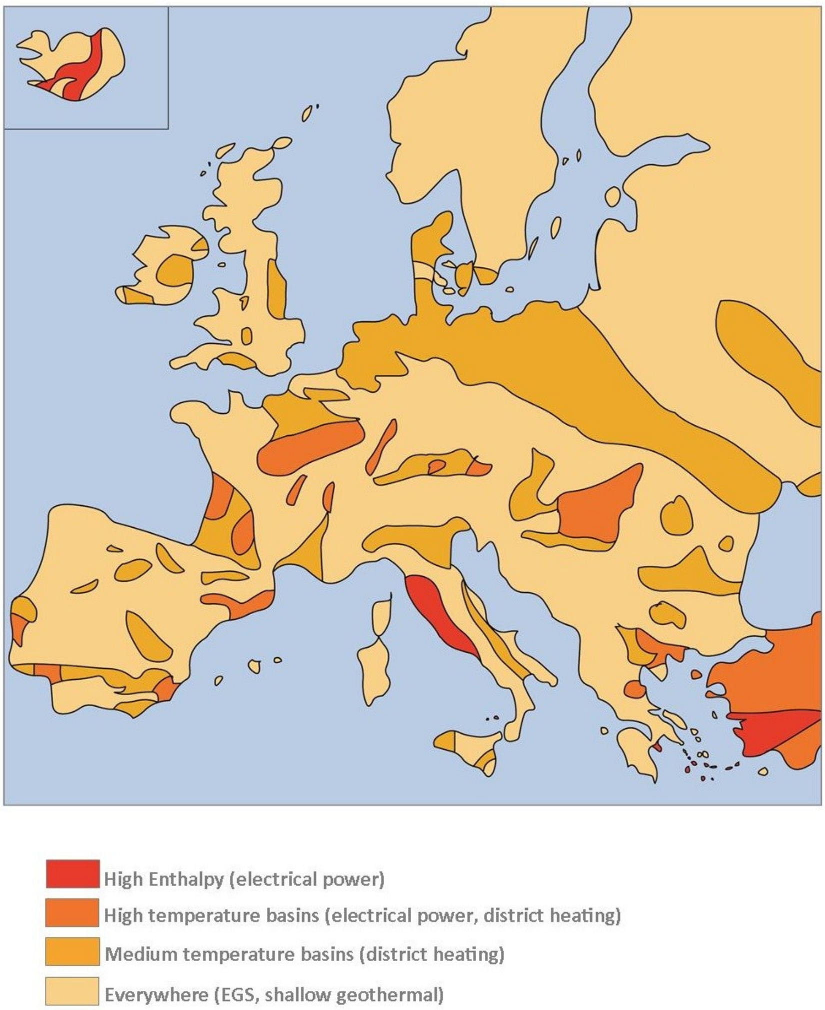


Figure 1 Geothermal resources in Europe

1.3 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.
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).
As Geothermal Heat Pumps can be considered a mature and competitive technology, a level playing field with the fossil fuel heating systems will allow phasing out any subsidies for shallow geothermal in the heating sector.

Although geothermal electricity and heat can be competitive under certain conditions, it will be necessary with R&D to reduce the levelised cost of energy of less conventional geothermal technology.

LCo of Geothermal Electricity	**Costs 2012 Range(€/kWh)**	**Average (€/kWh)**	**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)**	**Average (€/kWh)**	**Costs 2030 Average (€/kWh)**
Geothermal HP	0,05 to 0,30	0,08	0,05
Geothermal DH	0,02 to 0,20	0,06	0,04
Geothermal direct uses[1]	0,04 to 0,10	0,05	0,04

Figure 2 Levelised costs of geothermal technologies

Ref : Update of Strategic Research Priorities for Geothermal Technology (2012, European Technology Platform on Renewable Heating and Cooling)

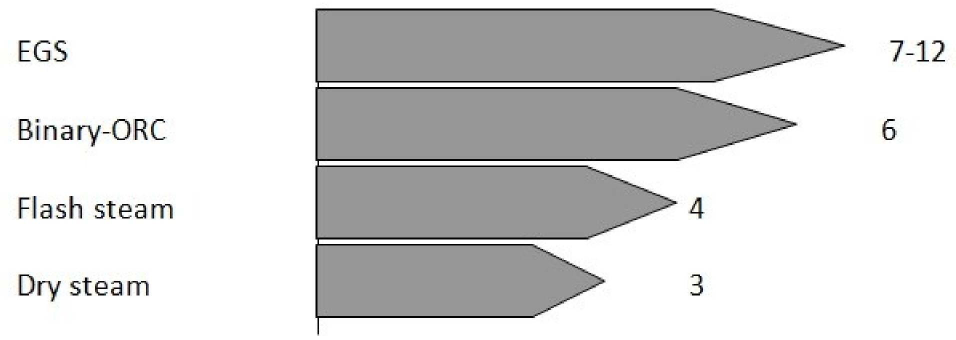
[1] Directs uses are geothermal applications in balneology, greenhouses, agro-industrial processes etc.

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.

Figure 3 Technology costs

Capital costs, € million /MWe installed



Geothermal heat technologies are also capital intensive with low O&M costs.
Capital costs, € million /MWth installed

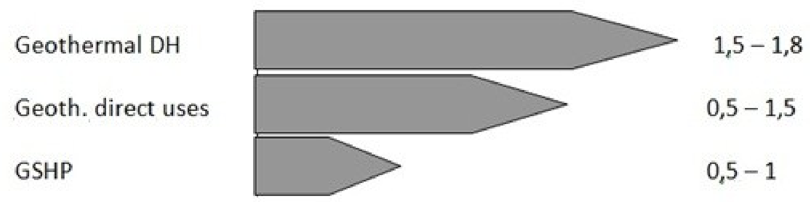


Figure 4 Capital costs of geothermal technologies

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 renewable energy, producing 24h a day, everywhere; i.e. a local energy source with limited network needs. Moreover, it allows at balancing the grid, being both baseload and flexible.
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.

Figure 5 Production costs

2. 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;

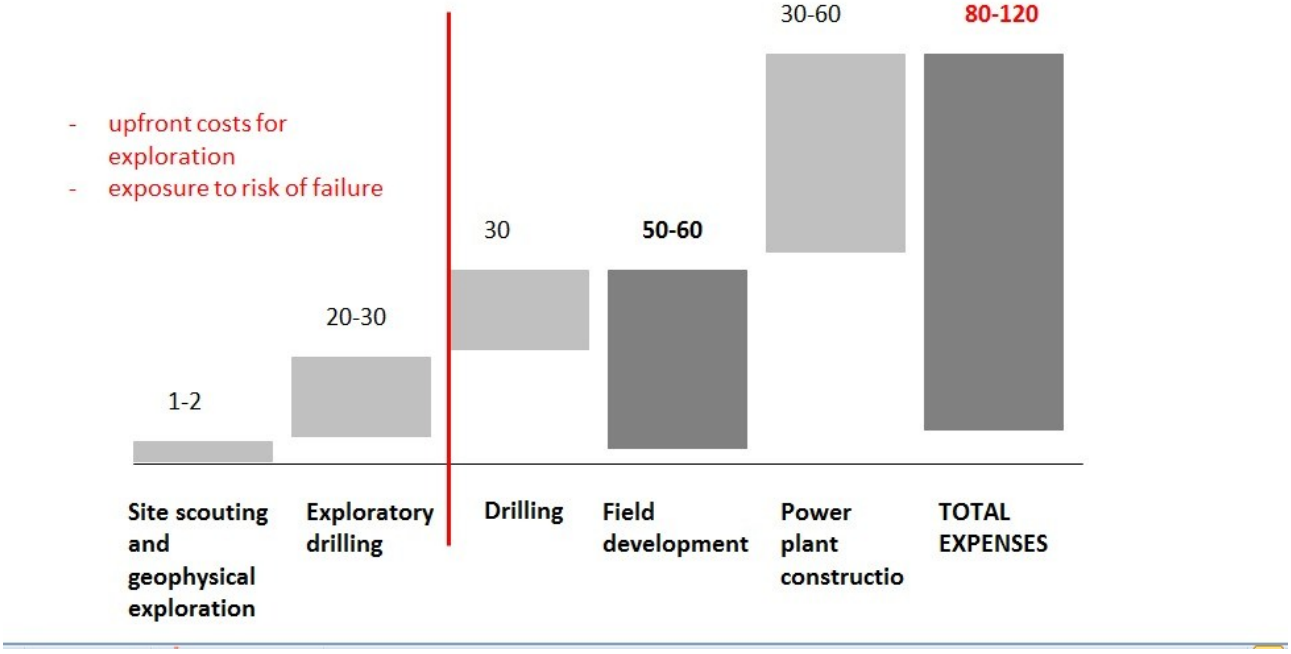
➢ The homogeneity of products derived from geothermal energy (e.g. power, heat, tradable emission reduction certificates) do not command a premium that can be levied nor enable the development of niche products;

2.1 Geothermal project financing

Capital costs for geothermal generation per MWe range between 4 and 7 million euro. 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

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



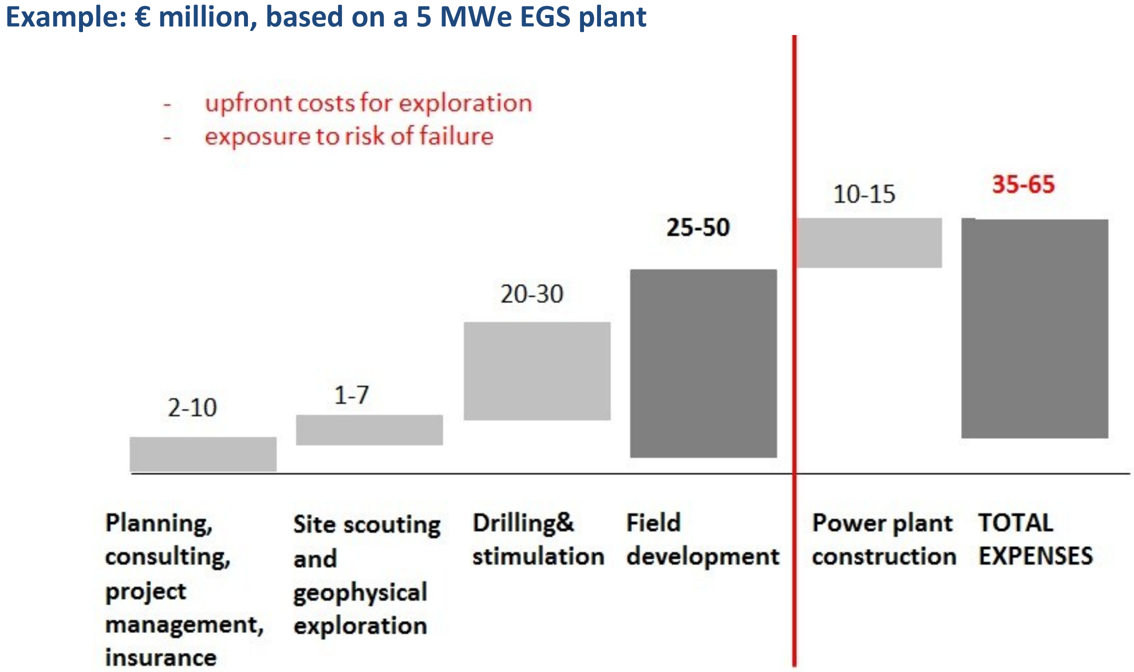


Figure 6 Examples of costs division for a geothermal power plants

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.

2.2 Mechanism for funding

As mentioned above, geothermal project development has high upfront costs that can take 3-6 years. Figure 7 below depicts the several phases of a geothermal project and presents the financial instruments, either public or private, needed in each of these steps.

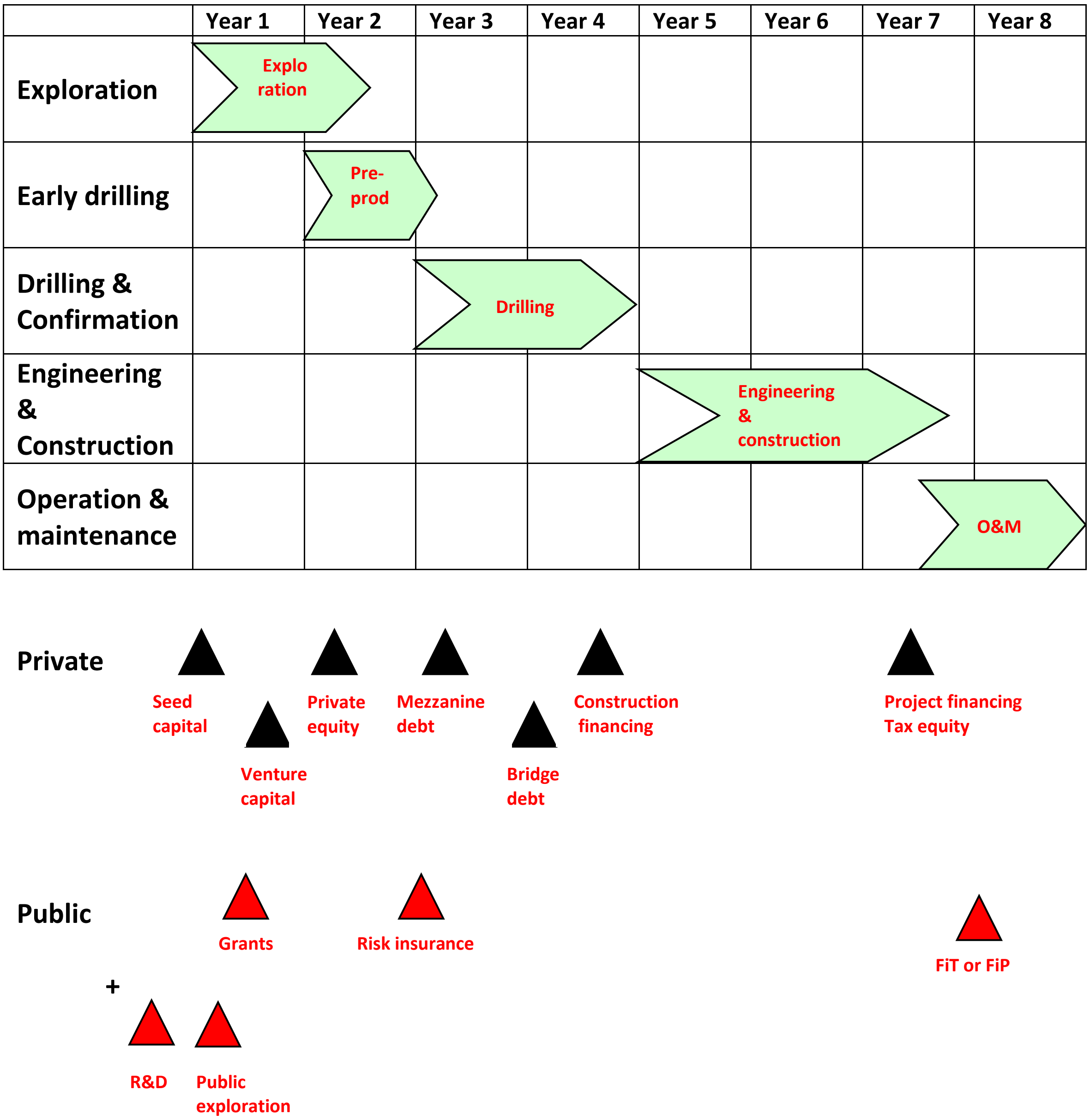


Figure 7 Mechanisms for funding

3. Existing mechanisms for funding at EU and national level

Several mechanisms for supporting investments in geothermal energy exist at European and national level. These mechanisms can address different project stages and can come from different sources. This chapter will present a brief review of the most common instruments currently in place.

3.1 Research, Development & Deployment

All technologies pass through the same stages of the innovation cycle: from basic research through development, demonstration, deployment, and commercial market uptake. During these phases public funding for the continuing industry-led research, development and deployment is needed.

Recent European Commission's documents[2] point out that how crucial is to invest in new renewable technologies and to improve existing ones through RD&D. Member States have spent €4.5bn on renewable energy R&D over the last 10 years with the EU spending €1.7bn from the Sixth (FP6) and Seventh Framework Programme (FP7), and the European Energy Programme for Recovery (EERP)[3]. However, as Figure 6 overleaf clearly shows, the allocation of these funds between different technologies across the energy sector was all but fair.

As a matter of fact, EU R&D funding allocated to geothermal energy during the FP6 and FP7 until March 2012 amounts to €29.4m. This is indeed negligible if compared to what it was allocated to other technologies. For instance, FP6 and FP7 funds for photovoltaic (PV) were as much as 10 times higher than those for geothermal. Moreover, to date the geothermal sector has experienced, together with biomass, a proportional reduction in FP7 (from €17.3m in FP6 to €12.1m).[4]

The EERP, a €4bn programme set up in 2009 to co-finance 59 projects designed to make energy supplies more reliable and help reduce greenhouse emissions, while simultaneously boosting Europe's economic recovery. However, no geothermal projects have been financed as this programme exclusively funded 44 gas and electricity infrastructure projects, 9 offshore wind projects and 6 carbon capture and storage projects.

Another financing instrument existing at EU level is the NER300 programme, so-called because Article 10(a) 8 of the revised Emissions Trading Directive 2009/29/EC contains the provision to set aside 300 million allowances (rights to emit one tonne of carbon dioxide) in the New Entrants' Reserve of the European Emissions Trading Scheme for subsidising installations of innovative renewable energy technology and carbon capture and storage (CCS).

In December 2012, the European Commission awarded NER300 funds to the *Geothermal South Hungarian Enhanced Geothermal System (EGS) Demonstration Project*. The Hungarian project is one of the 23 innovative renewable energy technology projects funded according to the outcome of the first call for proposals under the NER300 programme. A second call has been launched in 2013.

[2] See for instance the Communications "Energy Roadmap 2050" COM(2011)885 and "Renewable energy. A major palyer in the Europen energy market Com(2012)271.
[3] COM(2011)885.
[4] Pezzuto S., Sparber W., Fedrizzi R., Assessment of energy savings potential and EU funding for heating and cooling, 2012.

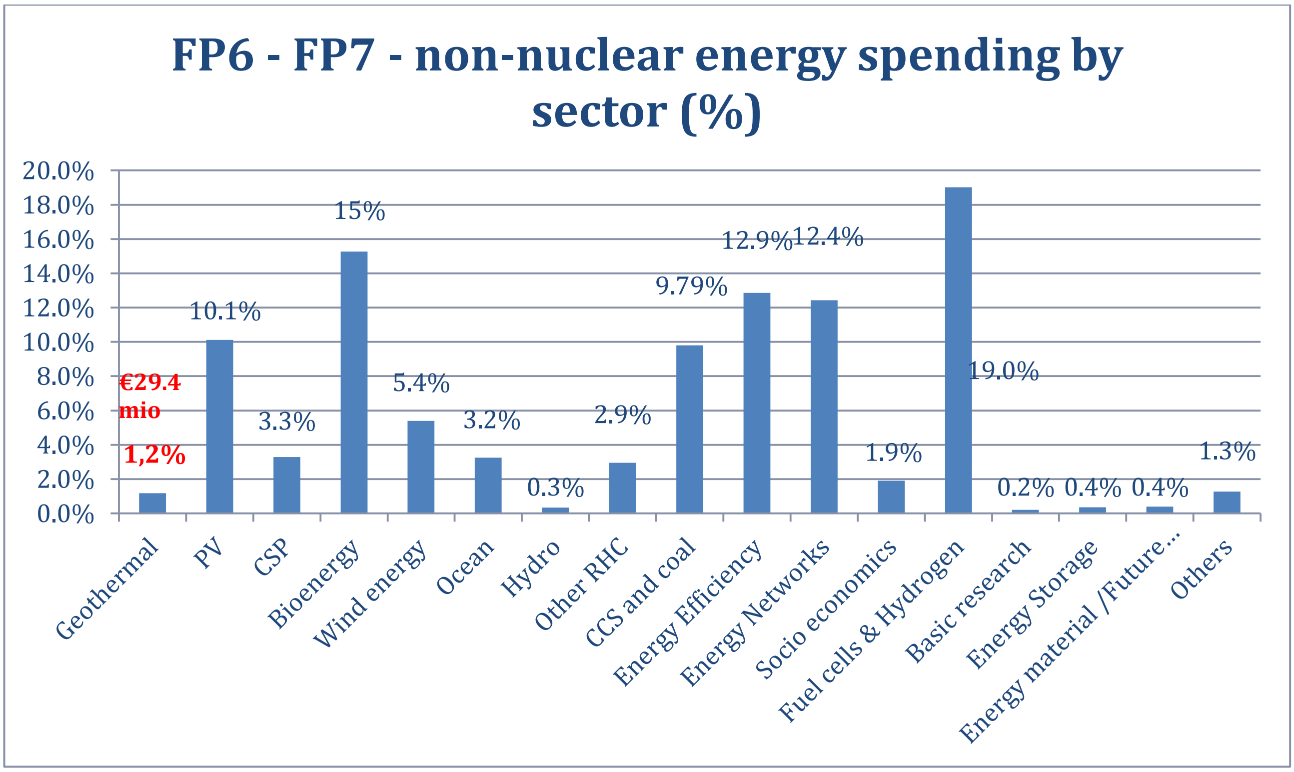


Figure 8 EU R&D funding allocated to energy technologies during the FP6 and FP7

From this analysis it is clear that geothermal is, amongst those technologies experiencing technological progress, the one receiving the smallest amount of financial support despite all the advantages it provides to the energy system (renewable base-load, no need for back up, alleviating the need for transmission and distribution infrastructure etc.).

While conventional geothermal power is already a most competitive energy source, low-temperature systems and EGS will become competitive within a few more years if substantial research, development and demonstration (RD&D) resources are allocated to those technologies. Likewise, geothermal heating and cooling also need RD&D funding to further improve the efficiency of the systems and to decrease installation and operational costs.[5]

Starting from the current discussion on Horizon 2020, geothermal should receive more attention as substantially higher RD&D funds are needed in order to become more competitive.

3.2 National geothermal risk insurance

Beyond exploration, the bankability of a geothermal project is threatened by the geological risk. The geological risk includes the risk not to find an adequate resource (short-term risk) and the risk that the resource naturally declines over time (the long-term risk).

[5] Strategic research priorities for the sector were developed in two distinguished documents: *Strategic Research Priorities for Geothermal Technology* (European Technology Platform on Heating and Cooling, 2012) and *Strategic Research Priorities for Geothermal Electricity* (TP Geoelec 2012),

Risk insurance Funds for the geological risk already exist in some European countries (France, Germany, Iceland, The Netherlands and Switzerland). The geological risk is a common issue all over Europe. Collaboration between Member States to remove it will allow them to save money.
For this reason the establishment of a Geothermal Risk Insurance Fund at the EU level could insure deep geothermal projects all over Europe.

In countries where geothermal developers might not internalise the resource risk into the costs of their projects, they may resort to private insurance policies. In Germany for instance, insurance companies and brokers are engaged in obtaining experience in relation to the resource risk. They provide adequate insurance policies to geothermal developers. In the rest of Europe however, the private insurance sector stands back.

In this context, some governments have taken action to settle a national insurance Fund in order to further develop geothermal projects (France, The Netherlands, Germany, Iceland and Switzerland).
Where such a Fund has been created, two insurance patterns may be distinguished, either:

- consisting of a post-damage guarantee;
- involving a guaranteed loan;

3.3 Financial support to geothermal electricity

National governments have been using a wide range of public policy mechanisms to support the development of renewable electricity technologies. These can be distinguished between investment support (capital grants, tax exemptions or deductions on the purchase of goods) and operating support (price subsidies, renewable energy obligations with green certificates, tender schemes and tax reductions on the production of electricity).

In a recent Staff Working Document[6], the Commission pointed out that the main support instrument in place in the EU is the feed-in tariff, i.e. a fixed and guaranteed price paid to the eligible producers of electricity from renewable energy sources. By increasing the competitiveness of electricity produced from renewables, feed in tariffs should 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 RES 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.[7]

Figure 7 presents an overview of the feed-in tariff (a fixed and guaranteed price paid to the eligible producers of electricity) systems in place in Europe. Only 11 countries i.e. Germany, France, Switzerland, Slovenia, Slovakia, Austria, Czech Republic, Greece, Portugal (Azores only) and Hungary have dedicated feed in tariffs for geothermal. Also in Spain there is a feed-in tariff system. Yet a moratorium is currently preventing any effective development.

The most attractive schemes are found in Switzerland (max. ct€33/kWh), Germany (ct€25/kWh for all projects and additional ct€5 for EGS) and France (ct€20/kWh with an energy efficiency bonus of up to 8 €ct/kWh).

[6] SEC (2011) 131: Review of European and national financing of renewable energy in accordance with Article 23 (7) of Directive 2009/28/EC
[7] ECOFYS et al, Financing Renewable Energy in the European Energy Market, October 2010

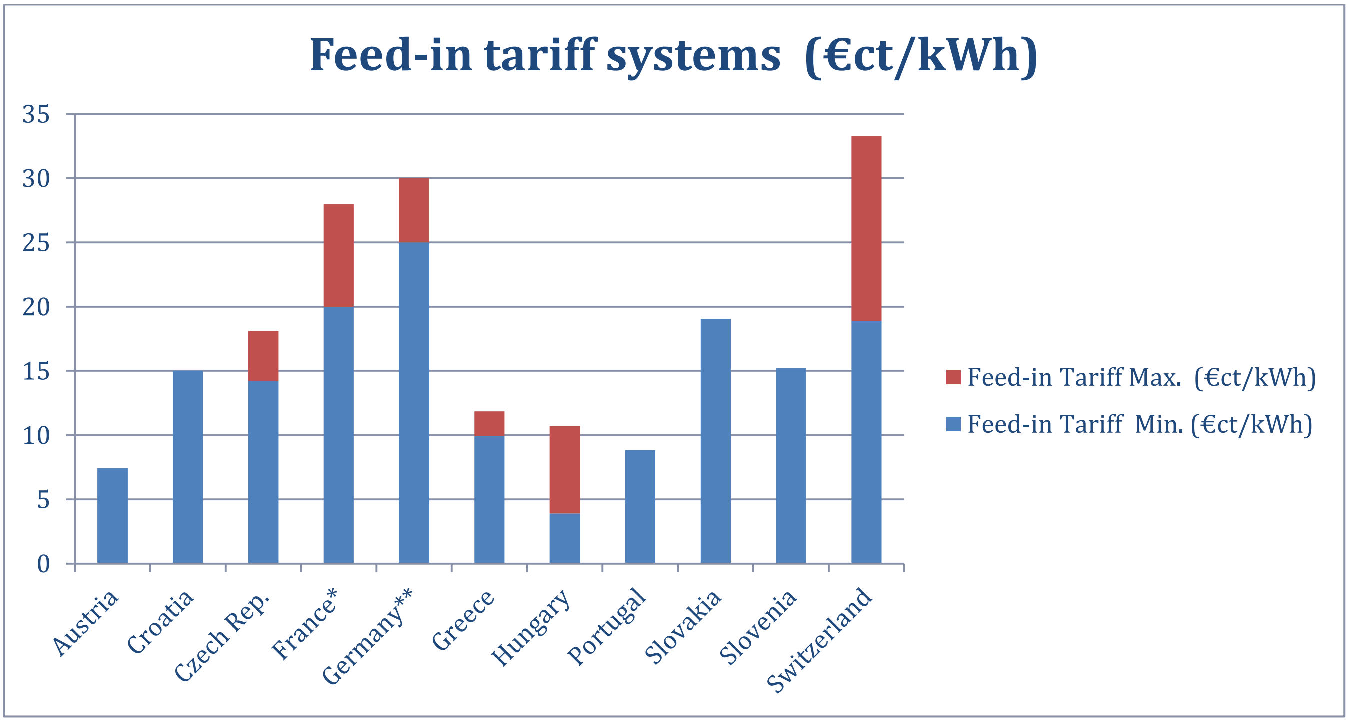


Figure 9 Feed-in tariff systems in the EU countries

*Applies to the produced net power
** Applies to the produced gross power

As shown in Figure 10 overleaf, 4 countries promote geothermal power generation by means of feed in premiums (bonus paid on top of the electricity market price) often as an alternative to feed-in tariff. These countries are Estonia, the Netherlands, Slovenia and Italy.

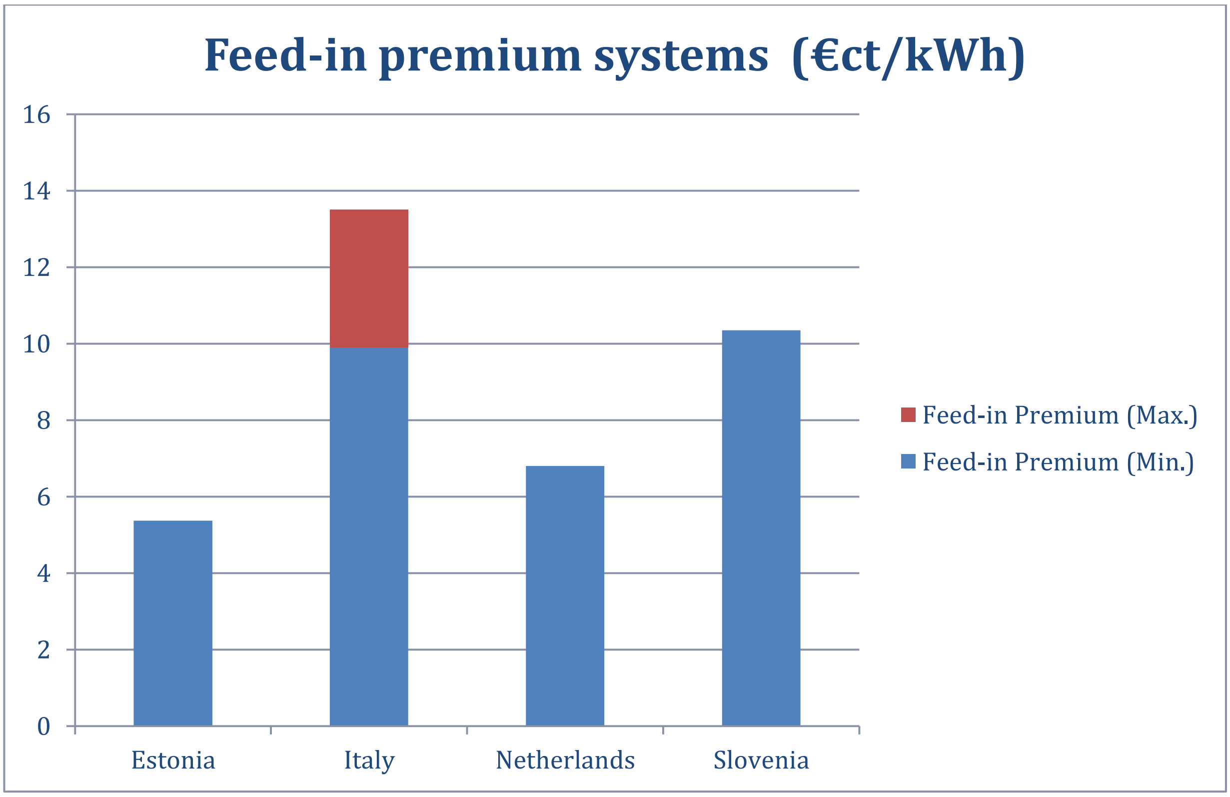


Figure 10 Feed-in premium systems in the EU countries

Last but not least, Belgium (Flanders), Romania, and the UK, quota/certificate systems have currently in place a quota system based on green certificates (Figure 11).

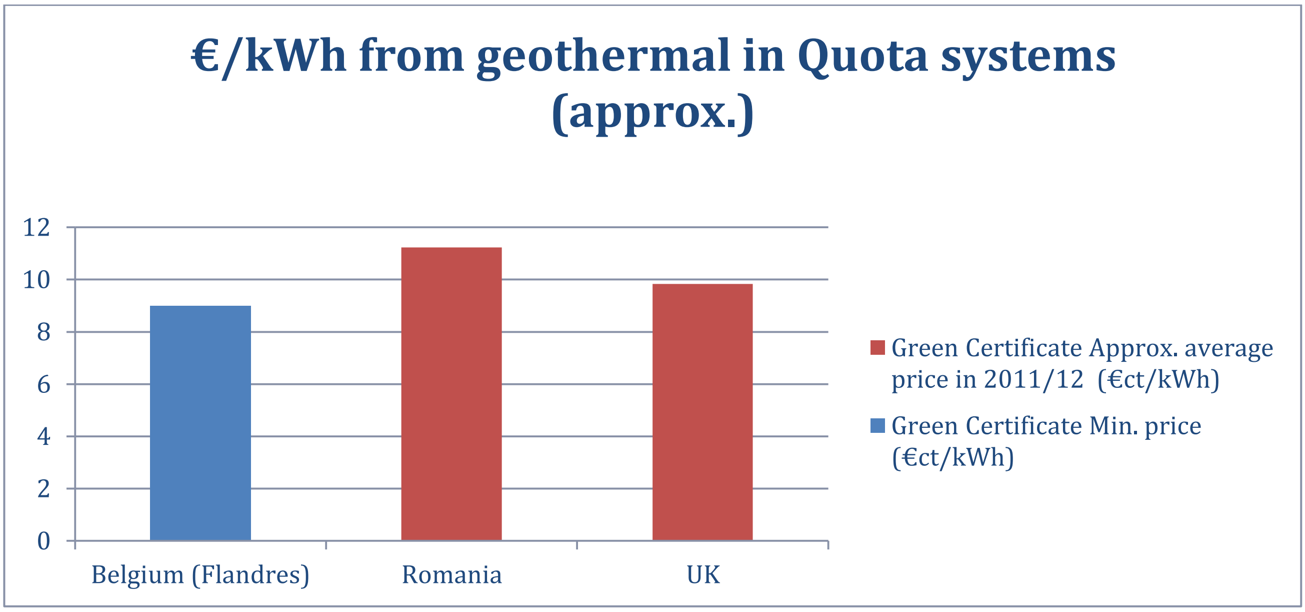


Figure 11 Quota systems in the EU countries

Policy makers need to set the type and level of support according to the maturity of the technology and of the market. However, from the analysis above it is clear that only a limited number of European countries support geothermal electricity effectively. In some cases, the level of support appears to be much lower than the one given to other renewable technologies at the same stage of maturity. Sadly, the rest of the countries do not support geothermal electricity at all.

Substantial support to some renewables, often overcompensating their real cost and bringing about windfall profits, has led to a reduction costs in these technologies. For this reason there is more and more support for mechanisms such as feed-in premium schemes that expose renewable electricity producers to market signals, i.e. the price of electricity. Against this background, it should be highlighted that this support was very much focused on some technologies and that most geothermal power plants have been running without support for decades.

As only a handful of geothermal projects have received operational aid over the last five years, it seems therefore premature to talk about the need for more market-based mechanisms or even phase-out financial support for geothermal electricity.

3.4 Financial support to geothermal heating

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 is now beginning to be explored in some Member States, partly because of the inclusion of the sector into the European regulatory framework (20% target).

The table below gives some (non-exhaustive) examples of financial mechanisms in force for geothermal district heating and ground source heat pumps:

Financial Support to Geothermal heating	
Investment Grants	France (Fonds chaleur renouvelable) for collective office buildings Germany Hungary Greece Poland Romania Slovakia Slovenia Spain
Feed-in tariff	Italy (Conto termico) Netherlands (SDE+) UK (Renewable heat incentive)
Tax rebate/VAT reduction	France: VAT reduction for DH, rebate on tax on revenues for individual housings Hungary Italy Netherlands
Low or zero interest loans	France: for individual housings Germany Hungary Netherlands Poland Slovenia Spain
CO2 tax	Finland, Sweden, Denmark

Figure 12 Financial support schemes for geothermal H&C in selected EU countries

The complexity of the sector as well as the variety and the predictability of tools used to support geothermal heat technology do not make the analysis easy. It is perhaps for this reason that the European Commission often dismisses the issue with a few lines stating that the heat market is local and requires local solutions.

However, there a the need for an in-depth analysis of the sector, including the best practises to promote geothermal heat, the synergies between energy efficiency and renewable heating and cooling, and barriers to competition, including the existence of subsidies for fossil fuels and the long-standing regulated price for gas.

4. Recommendations for financing mechanisms for geothermal

4.1 Recommendations over 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 in Feed-in Tariff Support 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 character 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
    - 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 an European Geothermal Risk Insurance Fund (EGRIF)

Rationale of the EGRIF

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 EGRIF aims at alleviating the shortage of insurance policies for the resource risk and ease investments in geothermal electricity projects.

Principles of the EGRIF

The EGRIF is meant to work through the pooling of the resource risk among geothermal electricity projects taking place in the EU. Besides, the Fund does not challenge the EU principle of subsidiarity nor act as a competitor to existing national insurance policies.

The EGRIF 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 EGRIF can be found in the Geoelec report.

4.3 Electricity

The types of financial incentives needed are:

- grants for first drilling (10-15 Mio € per well for EGS)
- geothermal risk insurance: see EGRIF proposal at EU level
- Feed-in Tariff / Feed-in Premium / Premium

- high temperature plants= to be determined according to the contribution for grid stability
- Low temperature and small high T° plants = ca 15 €ct/kWh
- EGS = ca 25 €ct/kWh
- a bonus to be added for Combined Heat & Power systems

Potential costs reduction

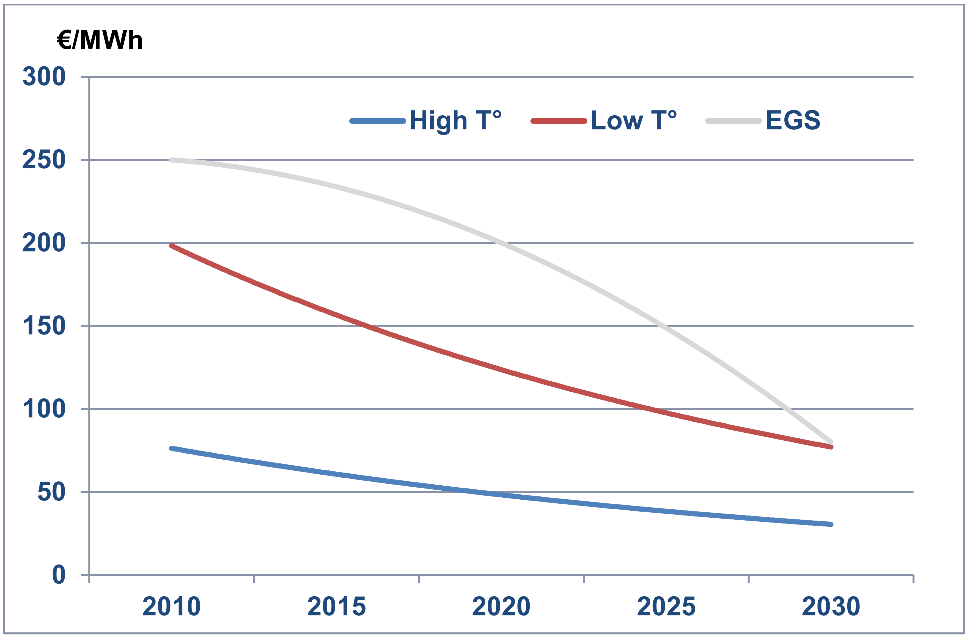


Figure 13 LCoE reduction for geothermal electricity technologies costs (€/MWh) 2012-2030

Towards Innovative financing for Geothermal

Level of maturity

The level and type of financial support should depend upon the maturity of the technologies.
The table below presents tariff digression and a proposal for a methodology for calculating the support level needed for the different geothermal technologies. The criteria mentioned also include some key cost elements needed to be used for the tariff calculation:

Market Maturity	Juvenile	Intermediate	Mature	After 2020
Criteria	0-6 deep geothermal wells are existing < than 3 plants are operational	6-60 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	na	7	6	5
Low temperature and small high T° plants	18	16	15	10
EGS	30	25	23	12
Support schemes	(repayable) Grants for seismic exploration, slimholes, and the 1st well	Feed-in Tariff	Feed-in Premium	Grid premium
Flanking measures	Public Risk insurance	Public or Private Risk insurance	Public & private Risk insurance	Private Risk insurance

Figure 14 Tariff digression for Geothermal electricity

Support schemes should be adapted according to the level of development of the deep geothermal market, and according to the technology (High temperature ; Low temperature and small high temperature plants ; EGS). Markets will become more mature with the drilling of more deep wells, giving information about temperature, flows, geology etc. Production costs will also decrease.

Financial support should firstly aim at the take-off of first deep geothermal projects with repayable grants for covering initial risk and capital for the first drilling suit for juvenile markets. Geological risk can only be covered by the Public as so few projects are concerned. When projects emerge in sufficient number, a feed-in tariff will allow for their development, in combination with a risk insurance public or private (as seen in Germany).
The more costs are competitive and markets mature, the less financial support is needed. A Feed-in premium can be more suitable.
Finally, the ultimate support, as long as the EU internal market is not fully completed, will be a grid

premium where geothermal is rewarded for stabilising the grid with its base load and flexibility, as more generation comes from fluctuating resources. The objective will be to provide a premium to geothermal plants for their capacity, ancillary services, and flexibility.

Regarding risk insurance, in a mature market with plenty of projects, private insurers could provide competitive solutions.

In line with the International Energy Agency's recommendations, policy makers need to adjust their priorities as RES deployment grows, taking a dynamic approach.[8] Tariffs should, therefore, be regularly reviewed so as to adjust the system to the latest available cost projections and, by doing so, to avoid windfall profits for producers.

Going beyond LCoE?

The definition of LCoE is the following:

$$LCOE = \frac{total\ lifetime\ expenses}{total\ expected\ output} = \frac{\sum_t^n \frac{l_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^n \frac{E_t}{(1+r)^t}}$$

With :

- LCOE = Average lifetime levelised cost of energy
- l_t = Investment expenditures in the year t
- M_t = Operations and maintenance expenditures in the year t
- F_t = Fuel expenditures in the year t
- E_t = Electricity generation in the year t
- R = Discount rate

Figure 15 Definition of LCoE

Therefore, the LCoE approach usually does not capture the following components:

- Systems factors like transmission other network costs such as impact on system balancing, impact on state/system energy security
- Externalities like government funded research, residual insurance responsibilities that fall to government, external costs of pollution damage or external benefits (e.g. value of learning to future generations)
- Business impacts like effects of fuel price and future revenue volatility, future changes in legislation, risks.

Externalities are notably emissions of GHG such as Carbon dioxide (CO2), Sulphur dioxide (SO2) and Nitrogen Dioxide (NO2), but also subsidies to fossil fuels and nuclear, electricity and gas regulated prices. They must be counted and ideally also the security of energy supply should be taken into account;

- Carbon emissions are counted through ETS (but only for the large energy plants)
- SO2 and NO2 emissions are not (except the example of the Swedish pool for No2)
- Gas price for heating: open market

The EU Emission Trading Scheme (ETS) has a conflicting objective of CO2 emissions reduction and promoting low carbon technologies. The current incertitude on its main goal creates the

[8] International Energy Agency, Deploying Renewables: Best and Future Policy Practice, November 2011.

conditions of its ineffectiveness with a CO2 price close to zero.

In a level-playing field, therefore, there is the need to include, as much as possible the above components or, as an alternative, to offer a bonus to geothermal for the benefits it provides to the overall electricity system.

4.4 Heating and cooling

Geothermal heating and cooling technologies are considered competitive in terms of costs, apart from the notable exception of EGS for heating. The establishment of a real level-playing field in the heating sector will allow phasing out subsidies for geothermal. But regulated prices for gas and other market failures must be corrected for creating an internal market.

Geological risk coverage is an issue also for geothermal heating:

- for deep geothermal, the same insurance fund than for electricity is required
- for shallow geothermal, open systems needs also risk coverage

Regarding shallow geothermal, one system exists in France (Aquapac). AQUAPAC is an insurance to cover the geological risk associated with aquifers up to 100 m depth. This scheme concerns only heat pumps with a capacity above 30 KW. It is a double guarantee, with two aspects:

- the research guarantee covering the risk to fail with lack of resources to run the installations
- the perennial guarantee about the risk of resource deterioration, during a 10 years exploitation period

District Heating and other direct uses

The type of support depends also according to the level of maturity on Geothermal DH in the country. Grants and Feed-in Tariff on heat are two possible schemes to be completed with insurance.

Geothermal heat pumps

Support schemes are here more for removing barriers like awareness. They can play a role in the promotion of geothermal. Financial incentives schemes are not available in all European countries for supporting Ground Source Heat Pumps (GSHP), although the competition on the heating sector can be considered as unfair with fossil fuels still receiving subsidies.

Financial support is still required in emerging markets where they should be tailored for both individual and collective installations. Possible schemes are grants, tax reduction, loans with zero interest rate. They should have a link with quality, certification etc.

Towards innovative schemes:

For heating systems of buildings, if a competitive renewable source of energy such as geothermal is planned to be installed but has high capital costs, this barrier can be removed with the following measure:

- an ESCO takes the responsibility of the investment (for example, the boreholes for individual or collective buildings, and eventually the Heat Pumps)

- Then, it sells to the customer the heat extracted for the borehole heat exchangers, via an adapted accounting system, at a fixed sale price, which is added to his electricity/gas invoice. Contractual conditions must be defined (duration for example).

Support schemes could cover the feasibility and design of such systems, while another possible innovative measure for geothermal heat pumps is the possibility of receiving discounts on the price of electricity.

Overall, geothermal heat technologies are, with some exceptions, heading for competitiveness. A level playing field with the fossil fuel heating systems will allow for phasing out any subsidies.
For instance, today a carbon price is not assigned to installations above 20MW, which is the largest part the sector. In order to fix the price of CO_2, a national carbon tax applied on all systems including small scale installations could be an efficient solution.

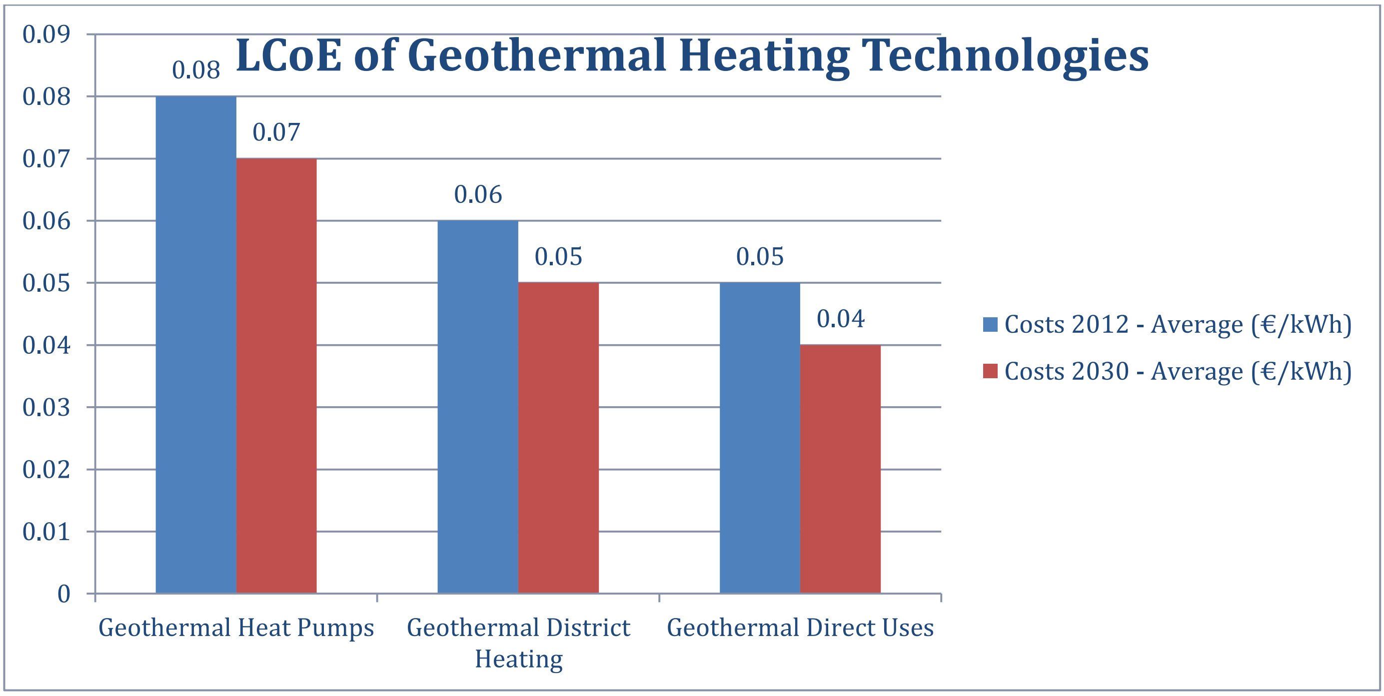


Figure 16 Levelised Costs reduction for geothermal H&C technologies 2012-2030

Ref : Strategic Research Priorities for Geothermal Technology (2012, European Technology Platform on Renewable Heating and Cooling)

Conclusion

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 European risk insurance system. A priority should be to create this scheme at the EU level, 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!