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Financing Geothermal: Innovative Support Schemes for New Business Models

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ABSTRACT

This paper aims to highlight the main financial barriers and the market conditions, 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.

The geothermal sector has steadily been growing over the past decade. Many new areas of Europe are now geothermal regions, and some countries that used to be marginal in geothermal energy are now key markets. This evolution was allowed by the direction of Research and Innovation (R&I) funding, public supports in form of capital investment or operating aids, in the pursuit of renewable energy objectives and the development of new financing schemes to channel this funding to geothermal projects. However, as progresses in renewable energy deployment have been significant, public policies are increasingly geared towards a greater exposure of such projects, including for geothermal energy, to market financing. This means that public support will increasingly be a complement to private finance instead of a primary driver of investment. Such an evolution poses the question of how geothermal projects can attract private financing, which business models and which financing schemes are currently being developed and what trends are emerging considering this challenge.

Geothermal energy projects are indeed challenging to finance and require specific schemes. Among the specific constraints embedded in the development of new geothermal projects, the geological risk and the very capital-intensive structure of project financing constitute a challenge that can slow down the deployment of new geothermal capacity. Moreover, the large diversity in the quality of geothermal resources and level of market maturity creates widely different conditions for geothermal project developers. To fund geothermal projects, it is therefore necessary to lay out the right financing scheme for the right project.

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.

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 taxpayers 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.

1.1 Clean Energy Investment Trends

Clean energy investments are clearly on an upward trend globally. Annual global new investments in clean energy increased by 24% between 2013 and 2017 when they reached USD 333.5 billion for electricity production (BILLIONEF, 2018). PV and wind represent a large share of the new investment in clean electricity production. In Europe however, the trend is rather one of a stagnation, if not a decrease in the amount invested annually in clean energy projects for electricity production. Indeed, investments in clean energy projects in Europe, including Turkey, went down from USD 88 billion from 2014-2016 to USD 69 billion in 2017 (BILLIONEF, 2018).

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 is now stabilised to a level close to the 2011 record.

It is further complicated by the fact 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 barrier can be tricky to overcome, especially with the European stock markets still uncertain and with banks exclusively looking for zero risk.

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1.2 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. 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.

The competitiveness of the deep geothermal sector could be consolidated by first developing a fair basis of cost comparison between energy sources which goes beyond a limited the levelized cost of energy (LCoE) approach, considering actual system costs and external factors. It includes analysing the ability of energy market models to properly remunerate the various benefits of geothermal energy in an industrial context of intensive capital investment (CAPEX) and marginal operational costs (OPEX). It should be noted that deep geothermal projects have low systems costs and negligible externalities, which means that the LCoE accounts for almost the full costs for the project. The case of Mexico can be highlighted here. Applying the principle of technology neutrality and a selection approach based on LCoE for the first auctions launched in 2015, the first Mexico Power Auction did not award any geothermal projects.

2. TOWARDS NEW BUSINESS MODELS IN THE GEOTHERMAL INDUSTRY

The main factors which influence the business models of the geothermal companies are the following:

- Policies: market liberalisation, state aid

The 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 carbon pricing in the heat market and the ETS price is still too low in Europe. Finally, there is the need of market transparency, including preventing lack of information provision to customers and taxpayers and a clear billing.

- Heat and electricity demands

The demand for more electricity in Europe is mainly linked with the economic development, more power supply in the transport sector and new IT applications. After several years of decrease, the electricity consumption is increasing again partly due to more demand for comfort too. But energy efficiency policies and measures have an impact on the electricity demand. We can forecast a relative increase at the horizon 2030. The transition towards a low carbon economy by 2050 means also more green electricity supply replacing fossil fuels power plants. Finally, Customer behaviour has an impact on the power demand, and the trends towards decentralised production will affect the electricity sector but also the geothermal market. All these factors are providing opportunities for geothermal power development.

Heating and cooling consume half of the EU's energy, but the heat demand is uncertain for the future. Energy efficiency gains will allow to decrease heat consumption, but the trend is uncertain in both the buildings and the industry sectors. The renovation rate is still low, and the level of new constructions is not high enough. The heat consumption reduction in the agriculture, services and industry sectors is also not big enough to impact the heat demand. Although the heating and cooling sector is moving to clean low carbon energy, 75% of the fuel it uses still comes from fossil fuels (nearly half from gas). This represents a huge opportunity for geothermal H&C supply.

- Integrating Geothermal De-Risking tools:

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 public Geothermal De-Risking Insurance Fund is seen as an appealing public support measure for geothermal.

- Capital costs and financing:

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.

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

- Prices options and new market design

Prices reflecting actual scarcity in terms of time, location, and available transmission capacity will indeed be key ingredients of the new market design, particularly to reward flexible production/consumption and a more balanced electricity technology mix having complementary specificities in terms of load factor, regional potential etc. As far as the generation side is concerned, flexibility should be rewarded also from the new generation of flexible renewable electricity technologies, including geothermal plants. Flexible renewable energy sources (RES) technologies can be used in partial load operation and in certain cases can quickly ramp their output up and down on demand. These technologies even change in the range of 20 to 100% with a speed of 2% per second could be achieved with proper management of turbine and by-pass valves, as has already been used according to the requirements of German legislation (see the case of the geothermal power plants operated by Stadtwerke München). Ongoing projects such as the GEOSMART project, financed by the European Commission Horizon 2020 are looking at solutions to upscale the use of flexibility resources from geothermal power plants while maximising the use of geothermal energy (with technical dimensions such as steam/energy storage and investigating policy and business models prospects). Operators of flexible RES installations can therefore offer ancillary services to system operators and provide valuable short and long-term flexibility at a regional level (including transborder), a step between centralised and decentralised systems. In this regard, it is worth highlighting how most balancing regimes (Germany being an exception) and infrastructure planners rarely take the potential flexibility from these technologies into consideration. The new market design should contribute to change this picture including through prices better reflecting scarcity. This approach can reduce over-capacity and alleviate the need for additional transmission and distribution infrastructure as well as costly storage. Overall, this will result in improved system adequacy, lower system costs and more social support for the transformation of our energy system.

2.1 "Sustainable Finance" As an Opportunity for Geothermal Energy?

As climate change mitigation takes an increasingly important place in the global economy, with the renewable energy sector for instance steadily growing in size, the private financing sector is increasingly developing financial products tailored to the demand of project developers for financing their renewable energy projects, and from investors who would like to be able to invest in this dynamic sector. As such, "sustainable finance" has rapidly emerged as a mean for private investors to distinguish investments in renewable projects, or more generally project that contribute to adaptation to climate change or to mitigating its effects, from the rest of the market.

At the European level, a regulation on Sustainable Finance is being established in order to clarify the framework and ensure that only projects that do contribute to climate change mitigation and adaptation. Among the priority of the proposed regulation is the establishment of a taxonomy that would define what constitutes a sustainable investment. Geothermal energy projects are explicitly identified as being among those considered as sustainable investments by the proposed regulation. The categorization of geothermal energy in the framework of the EU's sustainable finance regulation would for instance allow geothermal project developers to receive debt or equity financing from funds that are dedicated to sustainable finance. More generally, this taxonomy is likely to serve as a basis for different financial products that aim to foster sustainable development. It would for instance be an argument for the establishment of private geothermal risk insurance schemes in mature markets.

At a global level, the Climate Bonds Initiative has set a Standard and Certification Scheme which is a labelling scheme for bonds. The Scheme is used globally by bond issuers, governments, investors and the financial markets to prioritise investments which genuinely contribute to addressing climate change. Three Geothermal criteria addresses this issue with an emission threshold that projects must meet if they are to be certified: new and existing geothermal projects with direct emissions of less than 100gCO2/kWh; Geothermal projects with mitigation technologies that will render the non-condensable gas releases to the atmosphere negligible; Geothermal projects that have been reviewed and registered under the Clean Development Mechanism.

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2.2 Defining Market Maturity

Geothermal energy technologies are at different level of market maturity. While some technologies are quite proven commercially and widely available, some others remain at the early demonstration phase. Within the European Union, the metric of Technology Readiness Levels is widely used in R&I program to assess the maturity of a technology. However, this metric is only partially relevant when considering the capacity of a technology to be deployed and competitive on a fair market. For geothermal energy technologies, the question of defining market maturity is particularly important as the geothermal technology market is quite fragmented across uses and geographically.

Going beyond that technology readiness, several typologies aim to define a market maturity scale. Of these, the Commercial Readiness Index, developed by ARENA, the Australian Renewable Energy Agency, is worth flagging considering the institutional nature of its instigator. The CRI is conceived as a complementary scale to the TRL, adding 6 echelons ranging from “hypothetical commercial proposition” to “bankable asset class” (see figure below). The design of the CRI scale underlines the difference between technological maturity and market maturity. In the case of geothermal energy projects for instance, most cases fall within the scope of the CRI 3 to 5. In some markets, shallow geothermal systems fall for instance within the scope of CRI 6.

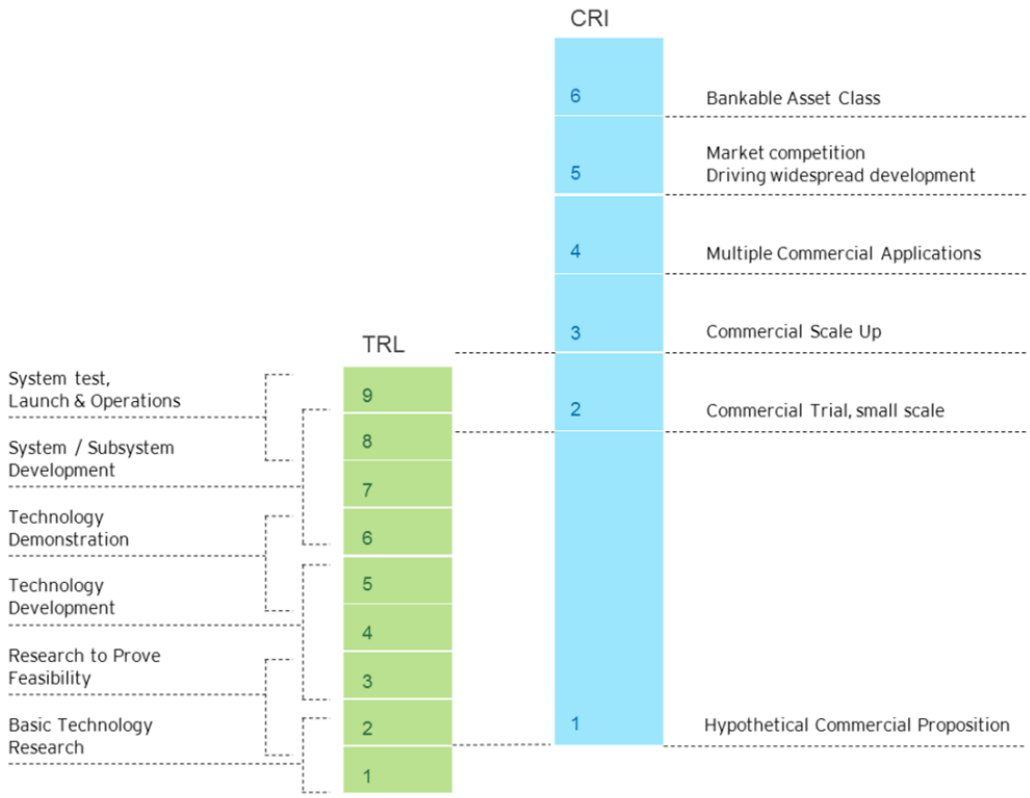


Figure 1: Commercial Readiness Index and technology readiness level (ARENA, 2014)

CRI scale (source: ARENA):

1: Technology is not commercially proven or test

2: Commercial demonstration projects

3: Specific policies enable the scale up of the technology commercially

4: subsidies remain important but several commercial applications in operation, debt and equity financing available, regulatory framework clarified

5: Long term policy driving developments, with competition within the supply chain (e.g. component manufacturers competing for bids, driving prices down)

6: Technology development driven by costs, profitability, and performance compared to alternative. Good information available on projects through a degree of standardisation or comparability to a large portfolio of existing projects and low risk for financiers (i.e. “normal” market risk)

Other scales to define market maturity exist. The scale defined by Kobos & al. establishes a market readiness level with the following levels: 1) access to market base, 2) Security of financial capital, 3) Manufacturing capability, 4) Market Competitiveness & profitability, 5) Consumer utility. This scale takes a slightly different approach to market maturity than the one used by ARENA, by considering market maturity through the lens of the “micro” components of the supply chain of a given technology rather than by considering the overall market conditions. The use of this scale is therefore of specific interest for investors and project developers to assess the quality of their value chain, while the ARENA assessment has a value for policy makers aiming to accelerate the progress of a technology toward market maturity.

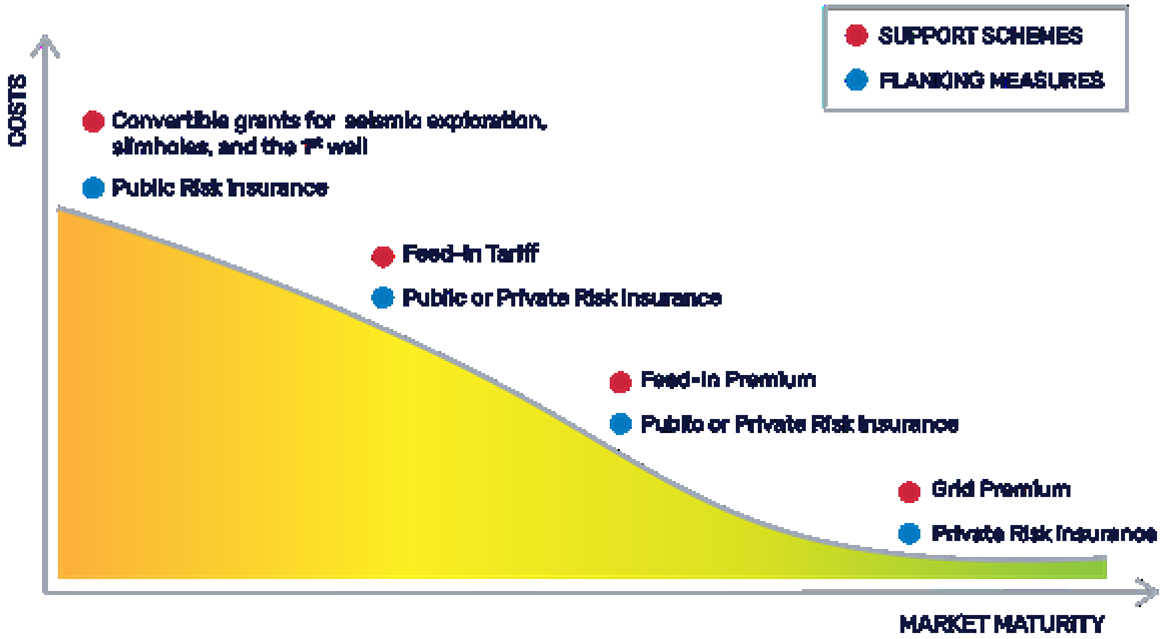


Figure 2: Recommendations on public financing, support schemes for Geothermal adapted to technology maturity (Source: EGEC)

3. PRICING: COSTS OF GEOTHERMAL TECHNOLOGIES

3.1 Economics of Geothermal Technology

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 cases of low to medium temperature resources, 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), industrial or tertiary sectors.

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 RD&I and enabling polices are still necessary to reduce the levelised cost of energy of less conventional geothermal technology.

Table 1: Cost of geothermal electricity technologies (incl. LCoE, systems costs and externalities) (EGEC)

Levelised cost of Geothermal Electricity	**Costs 2018 (€/kWh)**		**Costs 2030**
	Range	**Average**	**Average (€/kWh)**
Electricity Conventional – high T° (20 MWe)	0,035 to 0,07	0,045	0,030
Low temperature power plants (10 MWe)	0,13 to 0,19	0,15	0,07
Enhanced Geothermal Systems	0,26 to 0,40	0,30	0,12

Table 2: Costs of deep geothermal heating and cooling technologies (incl. LCoE, systems costs and externalities) (EGEC)

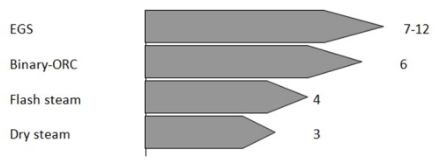
Levelised Costs of Geothermal Heat	**Costs 2018 (EUR/kWh)**		**Costs 2030**
	Range	**Average**	**Average (EUR/kWh)**
Geothermal Heat Pumps	0,05 to 0,30	0,08	0,05
Geothermal District Heating	0,02 to 0,20	0,06	0,04
Geothermal h&c applications[1]	0,04 to 0,10	0,05	0,04

3.2 Technology Costs

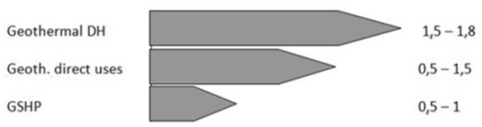
Investment costs: Geothermal electricity development costs vary considerably as they depend on a wide range of conditions, including resource temperature and pressure, reservoir depth, location, drilling market etc. See below the capital costs per geothermal technology.

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 for geothermal power, € million /MWe installed



Capital costs for geothermal h&c, € million /MWth installed

Figure 3: Capital costs of geothermal technologies, € million /MW installed (EGEC, 2019)

3.3 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 renewable energy sources (RES) and conventional technologies. Moreover, geothermal is a renewable energy with very low GHG emissions so external costs of pollution damage is negligible.

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

[1] Deep geothermal applications in balneology, greenhouses, agro-industrial processes etc.

3.4 Geothermal Tariff Design

The pricing of geothermal can be materialised by the power purchase agreements (PPAs) between geothermal companies and public power providers. On average, the PPA in the USA for geothermal power production is 75,88 USD/MWh but large differences exist between States. In Europe as well, wide differences can be observed in the level at which tariffs are set, reflecting the degree of market maturity for geothermal power plants. In Indonesia, a decree sets for the highest reference price at $0.155/ kWh for its auctioning.

4. FINANCING GEOTHERMAL PROJECTS WITH PUBLIC SUPPORT SCHEMES

4.1 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 taxpayers 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.

4.2 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 previous chapter 4.1, they help the technology to decrease its costs and compensate for market failures.

But it appears clear that financial incentive schemes must be designed according to the market maturity of the sector (figure 2 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. For geothermal project developers, the design of the auctioning of support can have a strong impact: auctions focussing on capacity installations or on productions, not accounting for other factors (e.g. cogeneration of heat, dispatchability, baseload production, flexibility) can set a framework where geothermal cannot compete entirely fairly. Moreover, more uncertain incomes related to greater exposure to the fluctuation in market prices pose a challenge to geothermal project developers, as uncertainty usually translates into higher financial costs.

A possible source of revenue for the geothermal sector to be able to compete in an electricity market 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.

5. NEW FINANCIAL INSTRUMENTS

5.1 Green Bonds and Sustainable Finance

Green bonds are a rapidly growing mean to direct financing to renewable energy projects and represent an opportunity for the development of the geothermal sector beyond public support in more mature markets. Green bonds are typically financed by the private bond market, although they may be emitted by all types of actors, from local authorities to national government, as well as private investors. To that end, although they do have an additional focus on financing sustainable investments, they also are bound to the usual obligation rules in terms of repayment for instance.

Green bonds differ from conventional bonds by embedding a reporting on the project financed and that they must be used to invest in “green projects”. In general, they represent an influx of capital that should be directed to projects for the energy transition – typically renewable energy projects – or for environmental protection. Key actors in green bond emissions include commercial banks, companies (notably large companies in the framework of corporate sourcing), public authorities (cities, governments), public financial institutions (investment banks, development agencies). One of the key issues regarding green bonds concerns the criteria considered for an investment to be deemed sustainable or green (GHG emissions of geothermal projects). The European sustainable finance regulation debated within the European Union institutions will be a crucial basis to set the criteria for the sustainability requirements of projects benefiting from green bonds.

Geothermal energy is typically considered to be eligible for green bonds investments, although some caveats may be considered regarding the nature of the project financed (and notably its environmental impact). Geothermal projects have been financed through green bonds by developers in Iceland, Kenya or Indonesia. Some multilateral lenders providing funds to geothermal projects have also been raising capital through green bunds (e.g. Agence Française de Développement).

In Europe, a new regulation on sustainable finance should allow more funding from this instrument. The ongoing negotiation aims also at setting environmental criteria on RES projects, and for geothermal on GHG emissions.

The Climate Bonds Initiative, an international, investor-focused not-for-profit, is working on mobilising the $100 trillion bond market for climate change solutions. The Green Bonds Markets 2019 is estimated at $250billion (it was $168.5billion in 2018).

5.2 Crowd Funding and Cooperatives

Crowdfunding and cooperatives are a widespread mean of investing in renewable energy projects, although not as prevalent in the geothermal sector as for other energy sources. Crowdfunding and cooperatives are typically financing schemes that rely on small investments by several investors or contributors. Typically, crowdfunding represents a small percentage of large renewable energy projects but may play a crucial role in facilitating public acceptability of industrial projects through shared ownership. The influence of the financial contributors remains to be assessed for such large projects as geothermal power plants, regarding their expectations, on the project development. A notable example of a geothermal project using crowdfunding as part of its financing scheme is the United Downs projects in the UK.

5.3 Corporate Sourcing of Geothermal Energy

Geothermal power and heat supply to industry is getting more popular. It can take several forms: Purchasing Power Agreement (PPA) which are an increasingly widespread mean for corporations or public authorities to secure their supply of renewable energy, Public Project Partnerships (PPP) or Joint Ventures (JV). More conventionally corporate PPA have been used – notably in beyond the EUin markets such as the US – by utilities to source power capacity, for instance from renewables. The benefit of PPA is to provide certainty for both parties: the energy producer has a higher certainty on income with a stable customer at a predetermined price. The customer benefits from certainty on price in the long term. In some cases, a corporate PPA may be the necessary element to start the investment in a renewable energy project.

Usually associated with renewable electricity, this type of contracts (or arrangements following similar principles) can also be used for heat supply to industry, agri-food or for space heating.

As geothermal power plants can also supply heat that can be used in industrial processes, Power Purchasing Agreement in the case of geothermal installations can also concern heat supply. A PPA can moreover be a key factor for the development of a geothermal demonstration project, either by providing support in the context of a joint venture for a demonstration project, or by reducing the financial uncertainty for project developers, and hence reducing capital costs. PPA can be “virtual” or “physical” when there is a direct connection between the plant and the customer. They can also be virtual PPAs where the electricity is fed at one end of the grid and consumed at the other. In the latter case, sound certification of the electricity consumption, for instance with guarantees of origins is necessary to avoid a double counting of the renewable energy consumed.

Corporate sourcing can also be done via a PPP as in the case of the heat supply from the Rittershoffen plant: the ECOGI project in France supplies geothermal heat to a biorefinery for process heat.

Another option is the Direct investment in production for self-consumption. Companies in a large number of markets also have the option of deploying renewable energy systems, on-site or off-site, to generate power or heat for their own use. In most direct investments in self-generation, the company becomes responsible for the entire project life cycle, from commissioning to de-commissioning, assuming the associated risks and financing responsibilities. The main example in the geothermal sector can be found in the Netherlands with the greenhouses managers developing and operating geothermal projects. Other example can be found in Belgium with the pharmaceutical company Janssen (J&J group).

Geothermal energy, as a flexible baseload source of energy is particularly suitable for the needs of a corporate sourcing, as it can respond to variations in demand and is available when needed. For this reason, there are several examples of geothermal corporate sourcing across the world and in Europe.

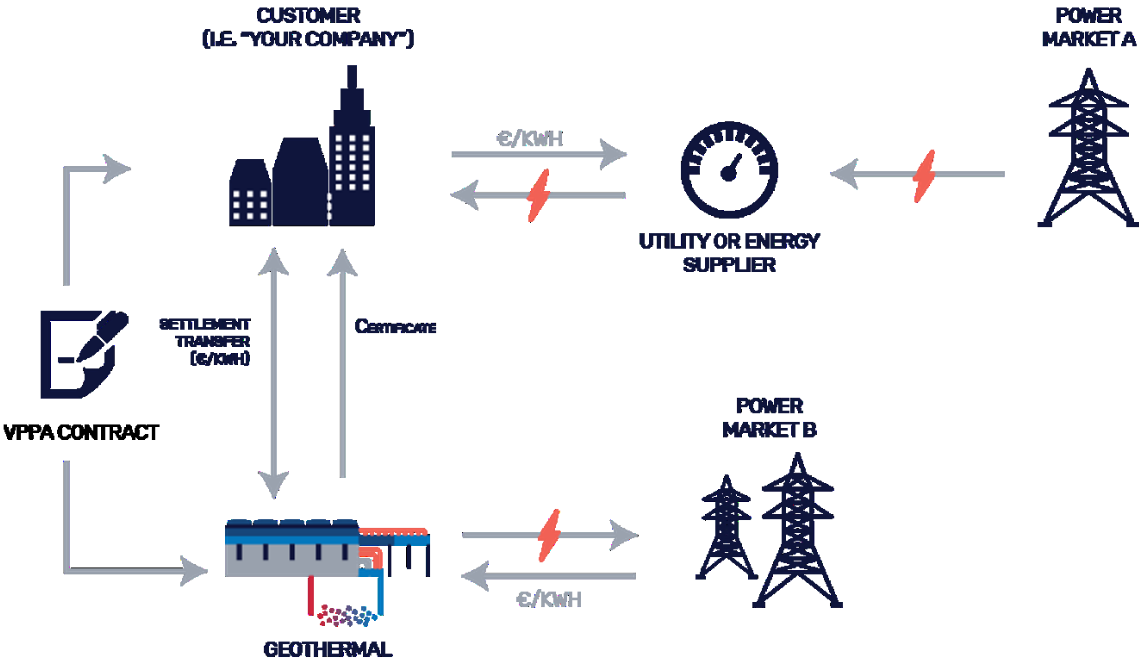


Figure 4: Virtual PPA for a geothermal powerplant (EGEC, 2017)

5.4 Auctioning

Auctions are an increasingly widespread way to allocate funding to geothermal energy projects – and renewable project by extension. Auctions for renewable energy projects are defined as follow by the IRENA[2]: "*Renewable energy auctions are also known as "demand auctions" or "procurement auctions", whereby the government issues a call for tenders to procure a certain capacity or generation of renewables-based electricity. Project developers who participate in the auction typically submit a bid with a price per unit of electricity at which they are able to realise the project. The auctioneer evaluates the offers on the basis of the price and other criteria and signs a power purchase agreement with the successful bidder.*"

For geothermal projects, auctions can make sense provided there are enough actors involved in the market and able to take part in the bidding process. It is therefore a financing scheme that is best suited for more developed markets.

Outside Europe, there have been successful example of auctions for geothermal electricity:

Indonesia: The auction was launched with a highest reference price of USD 155/MWh (USD 0.155/kWh) by the Energy Ministry[3]. The consortium of PT Hitay Southwestern Energy and PT Dyfco Energy won the auction for the Mount Talang Geothermal Working Area with an offer price of electricity of $0.1275/ kWh.

Mexico: During the 2nd Renewable Energy Auction in 2016, the GFE company was awarded an auction for developing a geothermal plant (25MW) at an expected cost of USD 0.039/kWh and receiving USD 0.0375 /kWh. This plant is an extension to an existing facility.

Kenya: The feed-in-tariffs in place until 2018 have been replaced by an auction scheme. While geothermal received around USD 0.088 /kWh (or USD 88/MWh) as a feed in tariffs, it is expected that upcoming auctions could result in support level twice as low, reflecting the significant maturation of the Kenyan market over the past decade[4].All figures and tables (beside the tables A-G at the end.

6. CONCLUSIONS

6.1 A System-Approach: the benefits of developing geothermal

The European countries are currently preparing their National Energy and Climate Plans 2020 to 2030, 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;

[2] IRENA and CEM (2015), Renewable Energy Auctions – A Guide to Design.

[3] Energy Ministry ministerial decree no. 17, 2014.

[4] Daily Nation, Kenya bets on cheaper power to fire its key growth engine, 11/02/2018

- 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.

6.2 Deploying geothermal

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 temporarily 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.

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