# Flexibility services and capacity availability: towards a business model and regulatory framework for geothermal plants market uptake

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## Abstract

In the European Union, the objective of decarbonisation of the economy 2050 laid out by the European Green Deal leads to rapid and profound changes in the structure of the electricity market. Transitioning away from a centralised system dominated by suppliers with high operational costs, the electricity network is increasingly dominated by renewable sources which are defined by low marginal costs. Because of a sharp increase in variable generation, flexibility and dispatchability is now more valuable, though the old market structure is not fit to reward them.

New regulatory instruments and business models are therefore emerging to allow the deployment of renewable technologies that meet the new needs of the electricity market. Geothermal plants, whose potential remains largely untapped across most of Europe, can benefit from this evolving regulatory framework and the apparition of new business models.

Capacity Remuneration Mechanisms in the 2018 European electricity market regulation can become an opportunity for geothermal power plants if they are implemented to incentivize new investments. The Power Purchase Agreement, an increasingly prevalent business model for private and public entities to secure a long term supply of renewable energy, values the stability provided by geothermal plant and can be a driver for new investments. The provisions introduced as part of the European Green Deal and the Fit for 55% package will further accelerate the transition towards renewable sources and the need to progress towards sector coupling. The GeoSmart project is exploring the policy, regulatory and financing framework that can allow the deployment and marketability of flexibility resources from geothermal energy at scale.

This paper will present the finding of the GeoSmart project, looking in a first time at the electricity market structure in Europe and flexibility needs. The paper will also present how geothermal power plants can meet the arising needs of the electricity market, and what new models for pricing and tariffication within the markets are suited to build the business case of geothermal ORC plants in Europe. The paper will also explore how business models, notably the Power Purchasing Agreement can complement the regulatory framework in accelerating the deployment of geothermal power plants as a flexibility and security of supply provider.

## 1. Introduction

Geothermal power plants are a renewable technology that traditionally provides baseload power generation. Geothermal plants have been operating in Italy for over a century, and there are today more than 15,7 GWe of geothermal power plant capacity installed globally, distributed throughout several countries, the largest users of which include the USA, Indonesia, the Philippines and Turkey. In recent years we have notably witnessed a rapid acceleration of the deployment of new

geothermal power plants beyond traditional markets thanks to key innovative technologies coming to market. Driven by the need for energy security in several countries, motivated by the various renewable energy policies implemented globally, a newfound interest in developing geothermal power capacity is also founded on the benefits geothermal plants provide to the electricity network. Indeed, although they have traditionally mostly provided baseload electricity, geothermal power plants are now being optimised to supply the increasingly needed flexibility for the electricity system. The European electricity market is an example of a system that has been overhauled in the past decade, having undertaken dramatic regulatory shifts to recenter the electricity market around renewable energy sources as part of the EU's climate and energy policies. New regulatory instruments and business models are emerging to allow the deployment of renewable technologies that meet the new needs of the electricity market. Geothermal ORC plants, whose potential remains largely untapped across most of Europe, can benefit from this evolving regulatory framework and the apparition of new business models.

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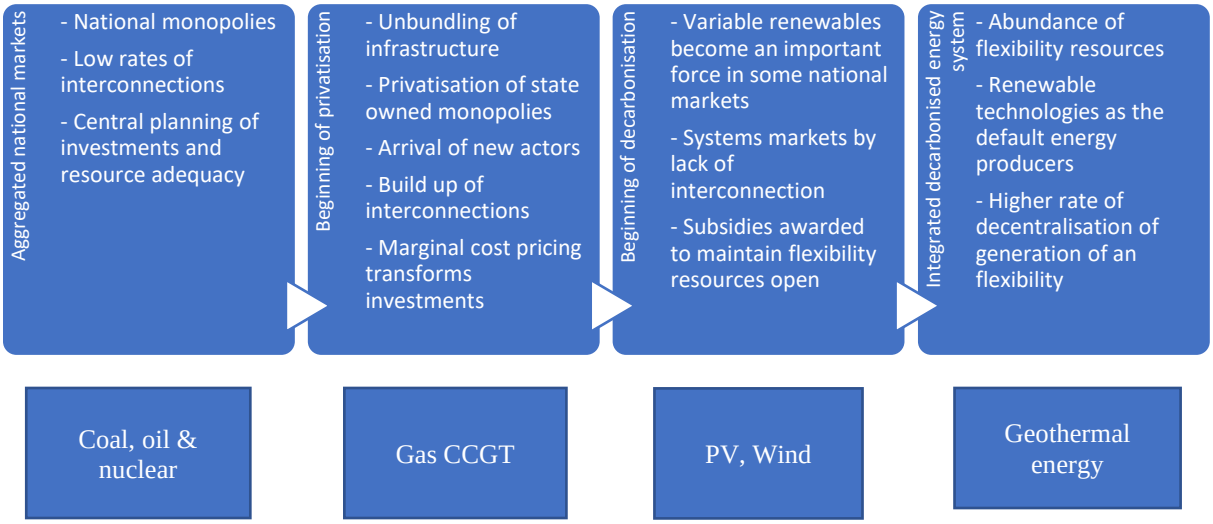
## 2. The European Electricity Market

The European electricity market is undergoing deep transformations, moving from a set of heavily centralised, fragmented national markets dominated by a single national company towards a unified European market where suppliers and consumers can benefit from competition. The move away from national monopolies led to the emergence of an electricity market where spot electricity pricing defined by the production cost of the marginal supplier at a given hour played an important role. This liberalized market incentivized investments in low CAPEX – high OPEX plants to provide flexibility, notably in the form of natural gas power plants. Simultaneously, a second transformation of the European electricity system happened with the rapid rise of renewable energy sources as a major component of the electricity mix.

Pushed forward by climate policies, and seeing their growth outpace expectation due to rapid cost decreases, high penetration of variable renewable generation capacity (notably solar PV and wind turbines) destabilised the European electricity market, with a depression of wholesale electricity prices in several countries, eating into the profit margin of most traditional flexibility providers. This notably pushed high OPEX assets out of the market. To adapt the European electricity market structure to these new constraints, the European electricity regulation and Directives were adapted as part of the 2016 Clean Energy Package, setting the European energy policy and regulatory framework to 2030.

## 2.1 Evolution of the European electricity market towards integration

With the progressive integration of national energy markets, and the transformation of the rules according to which electricity is sold, the European electricity industry evolved. The European Commission promoted the unbundling of infrastructure and generation (the same company cannot own the transmission lines and the power plants[1]), and the electricity market became dominated by hourly pricing determined by the marginal bidder.
Increased reliance on natural gas to generate electricity, and notably to provide flexibility to the electricity system, has been one of the consequences of this evolution. Gas power plants have low CAPEX, are quite flexible, depending on the price of gas for most of their costs.




With the expectation that renewable electricity production grows from 30% of the EU's electricity mix in 2016 to over 50% in 2030, the electricity market rules need to be adapted. The chief focus of this reorganization of market rules is to promote investments in flexibility resources, including energy storage and flexible renewable generation, to provide stability to a system with an increasingly high share of variable generation.

The new European regulatory framework on the electricity market is defined by two core priorities: putting consumers at the core of the electricity system and laying out a level playing field that allows a market for flexibility services to emerge. For geothermal power plant developers, while the focus on enabling individual consumers in the electricity market may have a more limited impact – although it facilitates the establishment of power purchasing agreements, or the establishment of mini grids around a geothermal power plant for instance – the focus on market-based flexibility has profound implications.

## 2.2 The new electricity market rules

Thus far, geothermal power plants across Europe could benefit from "priority of dispatch", which allowed geothermal suppliers to send all the electricity they produced to the grid at any time.

[1] https://ec.europa.eu/energy/topics/markets-and-consumers/market-legislation/third-energy-package_en

Coupled with the prevailing incentive schemes for geothermal power production – feed in tariffs and feed in premiums – geothermal operators where somehow protected from the income uncertainty linked with the variation in electricity market power prices.

The 2018 Regulation on the Internal market for electricity all but phases out priority of dispatch for renewable power plants, except for demonstration project of innovative technologies. To geothermal developers, this means that only demonstration projects will be able to continue operating according to the traditional geothermal power plant model. This will be the case of the first geothermal plant in a given country, or innovative projects such as an EGS in a new reservoir or projects that include innovative technologies such as mineral production. On top of the suppression of priority of dispatch, the European State Aid Guidelines on Energy and the Environment – the document setting the rules that support schemes established at the national level must follow to be aligned with EU law – incentivise the phase out of feed-in-tariffs in favour of alternative schemes that expose renewable power plants to price signals in the electricity market. The priority behind such regulatory changes is to avoid the inadequacy between power production and demand resulting from the rise of variable renewable power plants.

For geothermal energy, beyond demonstration projects, developers will have to behave according to the signals sent by the market. The following priorities of the regulation will have an impact on the framework in which new geothermal projects will have to operate:

- **Balance responsibility**: defined in the Article 5 of the Electricity Regulation, this obligation means that all market participants "shall be responsible for the imbalances they cause in the system". This responsibility is put at the core of balancing markets which are expected to take a prominent role in the structure of the European electricity market, providing an opportunity for income to participants such as geothermal power plants, which can modulate their output or ensure availability, to erase uncertainty in the market.
- **Dispatching:** as mentioned above, geothermal operators will see their dispatching rules change when commissioning new projects. Although existing plants will still be able to benefit from the dispatching regime they were following (i.e. priority of dispatch for their baseload electricity generation in most cases), new projects will have to comply with the new framework. In some countries, Member States may decide to set up a priority of dispatch for renewables, however this is no longer guaranteed at the European level.

These changes have consequences, as upcoming geothermal projects may be subject to redispatching, meaning that the plant may be prevented to sell its electricity to the system if there is too much supply and not enough demand. To prevent an excessive impact of curtailment on operators of electricity generating assets, several incentives to market flexibility are being introduced.

- **Capacity management:** a major consequence of the shifting structure of the electricity market is that it is difficult to guarantee the profitability capacity availability. Coal and gas plants, which made up the bulk of the EU electricity generation, are being pushed out of the electricity market by their lack of competitiveness due to their high OPEX and the pricing of their carbon externality. Moreover, the depression of the electricity market prices due to the high availability of renewable sources with low OPEX eats into the profit margin of fossil fuels power plants operations. In order to ensure the security of supply of the European electricity markets, several schemes are being introduced to guarantee the availability of dispatchable capacity to keep the lights up. The Electricity Regulation includes several criteria, from rules for European countries to set up such schemes, requirements to ensure the adequacy of their electricity generation capacity to how to manage congestion. The main innovation of the 2016-2018 review of the Electricity Regulation however is the introduction of capacity remuneration mechanisms, which allow electricity system operator to pay power

plants to stay available to ensure there is enough capacity if needed. These mechanisms raise many questions for the geothermal industry. The 550 gCO2eq/kWh threshold for eligibility of a given plant, which locks out some fossil technologies such as coal plants to some extent is still high. Indeed, geothermal power plants would have to compete with natural gas, among other resources, to secure access to Capacity markets. This means that CRM, as they are designed today, present a risk to provide a windfall to existing fossil based "flexible" assets, instead of creating incentives to invest in a new series of renewable energy flexibility assets such as geothermal power plants.

## 3. Incentivising Flexibility

The update of the European regulatory on the electricity system will create a shift in incentive schemes towards a greater reward given to flexibility. The GeoSmart project, funded by the European programme H2020 is looking to develop technologies to develop flexible geothermal projects able to answer the needs of the electricity system, and is also exploring how to retrofit existing plants. While the GeoSmart project is yet to deliver on the technical innovations it is pursuing, there are already examples of geothermal power plants providing flexibility or capacity availability. Altogether, even the traditional baseload operation of geothermal power plants can be a service of great value to the electricity system, and especially valuable to specific electricity users willing to secure their supply.

In Germany for instance, geothermal power plants have to demonstrate their capacity to meet strict balancing requirements on a technical level, i.e. their capacity to ramp up and down their power output from 100% to 30% in a matter of 15 seconds. However, as geothermal power plants in Germany do not have incentives to operate as flexibility providers, and baseload generation remains more profitable, they continue to operate as baseload producers. For geothermal operators to transform the way they manage their electricity generation towards valorising their flexibility and availability, clear financial and regulatory incentives are needed. The revised European policy and regulatory framework for the electricity system and renewables introduces some schemes that may provide the right incentives to geothermal operators.

### 3.1. Balancing Market

The updated rules on balancing markets are aimed at increasing the number of actors able to provide balancing services to the electricity system. Geothermal power plants, as they have demonstrated in their compliance with German flexibility requirements, can contribute to these markets which can provide some additional incomes to operators. In balancing markets geothermal power plants bid for providing balancing services at a given time. To simplify the scheme, geothermal power plants providing balancing services would be paid by the operators of variable renewable plants that create an imbalance in the electricity system when they produce too much or too little. Much like the current electricity market price formation, the marginal price of balancing would be the one paid to all service providers at a given time. It should be noted that the provision of balancing services is complementary to the usual operation of the plant. For instance, a geothermal plant could be producing baseload power, but contract downward balancing services.

### 3.2. Capacity Remuneration Mechanisms

These types of schemes are quite innovative in the European electricity regulatory framework. Capacity remuneration mechanisms allow geothermal power plants to receive an income for

maintaining dispatchable capacity in the electricity system when there is a risk that not enough capacity is available to meet the electricity demand of a country based on an adequacy assessment.

The capacity mechanisms are designed to incentivize the availability of market-based electricity generation capacity, and as such are a complement to the traditional market behaviour of power plants. They are designed in principle to internalise the cost of security of supply in the electricity market. Geothermal power plants can therefore benefit from Capacity remuneration as a baseload and dispatchable plant. However, in the current design of most schemes, there are little long-term certainties as to the financial benefit of supplying capacity availability to the electricity system, capacity mechanisms being required to be temporary mechanisms. This may be a barrier in justifying new investments in geothermal power plants, as the lack of confidence in the income linked with capacity availability has an impact on the financial risk of a project, therefore increasing overall costs.

Moreover, despite a threshold on the carbon footprint of plants eligible to participate, there are few barriers to the inclusions of fossil fuels (even coal plants emitting less than 350 kg CO2/kW per year on average are eligible in theory). This means that incumbent technologies are able to compete for capacity remuneration, further reducing incentives to invest in renewable based capacity availability at a system level and eating into the possible profit margin for geothermal providers of such a service.

## 4. Geothermal business models around flexibility

The evolving European electricity market regulatory framework is not yet providing quite the right schemes and incentives to facilitate investments in new geothermal power plants. Balancing markets and capacity mechanisms are not yet proven enough for a geothermal developer to integrate them when setting up the business plan for their geothermal plants. As it is often the case in the geothermal sector, the mitigation of the financial risk linked with project development remains a major factor in facilitating new developments. However, the flexibility and capacity availability of geothermal power plants is increasingly becoming an argument to attract investors in new capacity.

### 4.1. Auctions

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, having the value of geothermal integrated in the process.

The auction process provides policy makers with a great degree of flexibility in the design of the requirements. Auctions may be technology neutral or specific, focused on capacity or energy production, and include requirement for resource availability, diversity of portfolio or dispatchability. According to the parameters of an option – and the resource and market maturity – geothermal projects may or may not be competitive.

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. The consortium of PT Hitay Southwestern Energy and PT Dyfco Energy has 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.
- Typically, geothermal projects are competitive in the auction process when there is a well-established geothermal sector and when there are requirement for energy availability (i.e. flexibility, dispatchability or baseload production). Another feature of the auction process where geothermal projects may be very competitive is when the auction does not distinguish between the supply of heat and electricity. In this case, geothermal heating and cooling projects may be very competitive.

### 4.2. Corporate sourcing

Corporate sourcing of energy is used by corporations or public authorities to secure their supply of renewable energy. More conventionally they have been used – notably beyond the EU in markets such as the US – by utilities to source power capacity, for instance from renewables. The benefit of corporate sourcing 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 consumer benefits from certainty on price in the long term. Corporate sourcing of energy may take various contractual forms. It may correspond to Power Purchasing Agreements (PPA, where an agreement is made for the long-term sale of energy by two parties), to a joint venture or even to a corporation investing in its own geothermal project. CEPS identified the major role of price stability for stakeholders looking to enter into a PPA or other forms of corporate sourcing. Geothermal plants, as a provider of baseload electricity, or flexible generation are ideally suited to benefit. Indeed, there are several such examples across the globe, from aluminium smelters in Iceland, to Apple in California. In Europe corporate sourcing of geothermal power remains limited, considering the role of feed-in-tariffs in incentives schemes. However, there are many cases in the heating and cooling sector, which show that the cost structure of geothermal and the reliability of energy production is very consistent with the needs of corporate sourcing of renewable energy.

## 5. The 2021 energy price crisis

In the summer of 2021, carried by the recovery of industrial activities and of the broader economy globally, the price of gas started to rise rapidly. The crisis could have been a small one and a result of an overheating economy in the short term, however in Europe, a very cold winter emptied gas reserves, reducing resilience on this price short. Moreover, low wind, sun and heat waves created a need for electricity that variable renewables technologies were not able to meet. As a results, prices in the electricity market – defined by the pay as clear rule – started to skyrocket.

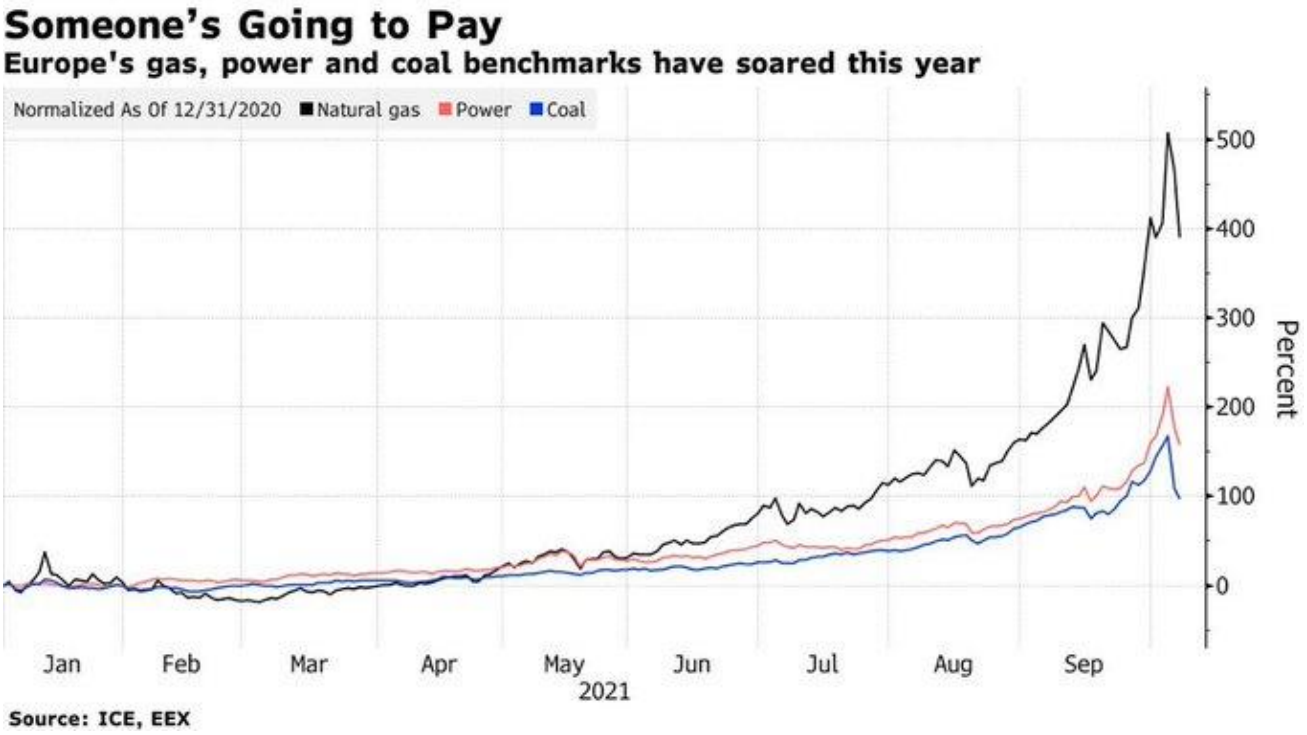


Fig. 1: Gas, electricity and coal prices growth in Europe during 2021 (ICE, EEX)

The rapid increase in prices had consequences on the electricity system, where gas power plants are usually in the position of flexibility providers. This status of gas prices is therefore leading to a tremendous energy costs crisis for European households that leads the European Commission to issue a special Communication for a Toolbox on Tackling energy prices.

Among the main conclusions of this Communication: "*Clear commitments to invest in climate neutral energy solutions across Member States will help reduce energy price volatility and imbalances in energy supply and demand brought about by movements in international fossil fuel prices, and other external factors. They are essential for keeping energy affordable for all consumers.*

*A successful green transition will lead the transformation not only towards clean energy, but also more energy efficiency and different use. The EU's commitment to significantly reduce its greenhouse gas emissions and fossil fuels consumption is fully confirmed by recent events. Measures need to be accelerated, both on the regulatory and investment side. The clean energy transition is the best insurance against price shocks like the one the EU is facing today. It's time to speed up.*"

Geothermal power plants, and other flexibility resources from geothermal energy – which should not be overlook such as demand side from geothermal heat pumps, seasonal underground thermal energy storage or the role of district heating and cooling in reducing electricity demand peaks – therefore have a key role to play in the stability of the European economy. Investments in infrastructure and capacity building for geothermal projects market uptake will however be necessary for this initiative to be successful.

**5. CONCLUSION**

As the energy sector is increasingly competitive while fossil energy sources continue to benefit from massive and systemic subsidies, geothermal energy developers are looking to new income streams to increase the profitability of their projects. This includes the provision of flexibility services to the energy system, where schemes for the remuneration of this service need to be put in place. It also includes developing entirely new geothermal products, combining the production of electricity with the extraction of strategic minerals like lithium from geothermal brines and signing long term supply contracts with battery factories.

The evolving electricity market rules in Europe represent an opportunity to improve the business model of geothermal power plants as the support schemes evolves. In their current state, schemes such as balancing markets or capacity remuneration mechanisms still embed too much uncertainty to contribute to improving the business case of geothermal power plant, therefore not providing the necessary certainty at early stage of project development to reduce project financing costs. However, at a later stage in the development of a project, typically when designing the turbine system, these schemes are an important component to integrate as they will inform how the geothermal plant is going to be used.

Innovative technologies allow the optimal use of geothermal power plants. They have proven their capacity to deliver baseload electricity generation and act as flexibility providers. The provision of electricity system services such as flexibility, energy security is poised to be among the core drivers of future geothermal electricity developments in Europe. Staving off future energy price crisis will be a key driver of future geothermal power developments.

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More information on the GeoSmart project: https://www.geosmartproject.eu/

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