D8.3 Policy formulation and liaison with decision makers

Project acronym:	**GeoSmart**		
Project title:	Technologies for geothermal to enhance competitiveness in smart and flexible operation		
Activity:	LC-SC3-RES-12-2018		
Call:	H2020-LC-SC3-2018-RES-SingleStage		
Funding Scheme:	IA	**Grant Agreement No:**	818576
WP 8	**Policy issues and integration opportunities**		

D8.3Report on policy formulation and liaison

Due date:	31/12/2023	
Actual Submission Date:	25/01/2024	
Lead Beneficiary:	EGEC	
Main authors/contributors:	WP8 partners	
Dissemination Level[1]:	PU	
Nature:	Report	
Status of this version:		**Draft**
		Final version
	X	**Submitted**
Version:	final	
Abstract	This deliverable deals with policy formulation and liaison with decision makers as part of WP 8 Policy issues and integration opportunities, about geothermal electricity to generate flexible power.	

REVISION HISTORY

Version	Date	Main Authors/Contributors	Description of changes
0	03/11/2023	Madeline Vander Velde	Agreed draft table of contents
1	08/12/2023	All WP8 partners	1st draft version
2	15/12/2023	WP leader	2nd draft version
3	20/12/2023	WP leader	Final draft version
4	11/01/2024	Coordinator	Review
5	25/01/2024	WP leader	Final version

[1] Dissemination level security:

PU – Public (e.g. on website, for publication etc.) / **PP** – Restricted to other programme participants (incl. Commission services) /

RE – Restricted to a group specified by the consortium (incl. Commission services) / **CO** – confidential, only for members of the consortium (incl. Commission services)

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 818576

This project has received funding from the European Union's Horizon 2020 program Grant Agreement No 818576. This publication reflects the views only of the author(s), and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Copyright © 2019-2024, GeoSmart Consortium

This document and its contents remain the property of the beneficiaries of the GeoSmart Consortium and may not be distributed or reproduced without the express written approval of the GeoSmart Coordinator, TWI Ltd. (www.twi-global.com)

THIS DOCUMENT IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS DOCUMENT, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Document: D8.3 Policy formulation and liaison with decision makers

Version: Final

Date: 26 January 2024

CONTENTS

Summary

This deliverable deals with policy formulation and liaison with decision makers as part of WP 8 Policy issues and integration opportunities, about geothermal electricity to generate flexible power. GEOSMART factsheets have been published for policy formation on geothermal electricity. The messages are presented in Chapter 1.

After the adoption of the first electricity market design (EMD) package, Member States started the implementation of the directives and regulations of this EMD package.

GEOSMART monitors these legislations and looks at the new market conditions to see how geothermal base load and flexible electricity generation can contribute. It helped to draft first policy recommendations on EMD implementation.

During the first phase of this activity, project partners liaised with stakeholders involved in the geothermal market and the electricity market design to establish liaison with:

- EU authorities: European Commission, new Members of the European Parliament in particular from the energy (ITRE) committee, and representatives of Member States in the Council
- National authorities: regulators and decision makers

GEOSMART partners then established national for a to organise the liaison at national level. As for liaison with decision makers, the project partners VITO, METU, COSVIG, and ON report the results of the stakeholder mappings they conducted in their respective countries. Selected stakeholders had the opportunity to contribute to the policy debate in 'national forums' (section 2.2).

First results from the project allowed partners to develop policy proposals based on these results: more flexibility from geothermal systems.

The covid-19 pandemic and then the invasion of Ukraine by Russia were two important factors which disturbed the electricity market. GEOSMART published there its first policy factsheet '*energy prices: the geothermal answer*'. This proposal was presented to EU decision makers.

These first policy proposals were on the agenda for the meetings of the national fora.

Finally, EU authorities decided to design a new electricity market design to answer the challenges of high electricity prices. GEOSMART contributed to the debate by formulating new position in a second factsheet: '*Geothermal power plants in the electricity market*'.

The benefits of geothermal power were presented:

First, geothermal power has the best load factor (typically higher than 80%) and is able to be dispatchable with flexible generation: ramp down and up the electricity generation in 15 seconds from 100% to 20%. GEOSMART project aims to support the development of geothermal dispatchable generation to be programmed on demand at the request of power grid operators, and according to market needs.

The 142 geothermal power plants in operation in Europe, with an installed capacity of about 3.5 GWe, are generating more than 22 TWh.

It also supplies lithium for storage in batteries and underground thermal storage for short and seasonal storage. It means that geothermal brings a burden on electricity grid, a contrario it offers services for grid balancing. For non-price criteria in costs comparison, geothermal has little systems costs but many system benefits.

As a local power source, being renewable with low GHG emissions, with low impact of land, it has little externalities and costs associated with it.

All these elements must be included in tendering and referred in legislation.

The European Commission recognised the value of geothermal power by listing geothermal has one of the five electricity technology to support in its recast EMD (Article 19b: Direct price support schemes for new investments in generation). The value of storage as promoted in GEOSMART was also recognised in the

electricity package (COMMISSION RECOMMENDATION of 14 March 2023 on Energy Storage – Underpinning a decarbonised and secure EU energy system).

Furthermore, to convey the main findings of the GeoSmart project and to allow for knowledge transfer among stakeholders for improving the market uptake of geothermal, two capacity building events about flexible technologies and business models were organised which are reported in section 2.3. Flexible technologies and business models are then further developed in the following sections.

The relationships created with stakeholders through the national forums and other capacity building events will be used until the project ends to inform them about the future results of the GeoSmart project.

1. CHAPTER 1 – COMPILATION OF POLICY FORMATION

1.1 Policy messages

What is geothermal electricity?

- **PUBLISHED**: August 30, 2019

Geothermal is currently engineered as an "always on" baseload supply, due to the limited flexibility to throttle the well without scaling and liner fatigue problems, and it is engineered for maximal efficiency at this output level. Geothermal Energy needs to exhibit a high level of fast flexibility to function as a fully reliable and controllable energy source. GeoSmart aims to optimise and demonstrate innovations to improve the flexibility and efficiency of geothermal heat and power systems

Technologies

Geothermal electricity exists for 110 years. A key feature of geothermal power is its near permanent supply of renewable electricity coupled with its flexibility. What makes it especially efficient for electricity supply, is that it can sustain baseload needs consistently and no matter the time of day or day of the week.

Over 1 GWe of geothermal energy is currently installed in the EU, generating 7 TWh/year. This number needs to quickly ramp up to meet the EU's 2030 and 2050 climate and energy targets. EU Proposal on electricity market design helps geothermal by providing support measures that value the additional services it provides to Europe's electricity system such as grid management, system adequacy, flexibility and resilience. Geothermal provides many additional benefits such as i) grid stability with a base load generation, ii) thermal storage and iii) flexible generation where needed and when needed.

It is made from processing of thermal energy in the form of water and/or steam that comes from reservoirs below the Earth's surface. The steam that is produced is then used by the geothermal power plant to produce electricity.

What are the different technologies and how are they used?

- Binary cycle power plants use a working fluid to heat geothermal brines to a specific temperature. The brine is then recirculated underground, where it is reheated by the geothermal heat source and goes through the same sustainable process again.
- Steam power plants use the steam and hot water from natural geothermal sources under the Earth's surface in order to power the turbine and generate electricity.

In addition to electrical powerplants, cogeneration or combined heat and power (CHP) systems are used to recover remaining excess heat and use it in district heating systems.

Values

Geothermal electricity is….

- **European:** The first power plant was invented in Larderello (Tuscany), Italy, in 1904 by Prince Piero Ginori Conti of Trevignano.
- **Available everywhere all the time** providing renewable electricity combined with heating, cooling, seasonal storage, grid stability and flexibility in 10 EU Member States and four neighbouring countries. 1 GW is installed in the EU producing **7.85 TW_h per year** assuming a 80% capacity factor and 2 GW_e in the rest of Europe. **10 GW_e should be installed by 2035**, provided the EMD and Renewable Energy legislation are implemented and well-designed.
- **Longest lifespan:** Geothermal power plants have the longest average lifespan of electricity generation capacity ranging up to 50 years and beyond. The oldest operational plant dates from 1986, **37 years** ago. 21 of the 142 operational plants in Europe are older than 25 years whilst 53 are older than 15

years. The average operational lifetime for nuclear is 20-40 years, wind 20-25 years, solar PV 30-35 years, coal 46 years and gas 25-30 years.

- **The most reliable electricity source:** Geothermal is also one of the most reliable sources of electricity. The International Renewable Energy (IRENA) assessed the load factor of geothermal electricity, nuclear, fossils, wind and solar PV. This reported that each MW_e of geothermal installed produces significant volumes of renewable electricity as well as **vital co-benefits** such as baseload renewable heating and cooling as well as the most sustainable extraction of lithium and other minerals.
- **Resource efficient:** The 16.5 MW_e Velika 1 geothermal power plant in Croatia, provided as much electricity as the 309 MW_e installed capacity of solar PV installations in 2020. The 20 MW_e Slatina 2 geothermal plant started construction in 2021 to more than double Croatia's renewable baseload renewable power output and finance has been agreed for the Slatina 3 power plant. Cindrigo Geothermal Ltd, the owner, is securing licenses for an additional 1,000 MW_e capacity.
- **Made in Europe with high sustainability:** Geothermal is a fully European industry. It does not consume critical raw materials and its supply chain for steel, cement and chemicals is housed within the EU. Moreover, geothermal is one of the largest exporting renewable technologies. Geothermal turbines are exported to over 81 other countries and European expertise is helping Green Sinopec invest in geothermal applications in Beijing and elsewhere in China.
- **A source of sustainable battery-grade lithium and other minerals:** Geothermal operations in Germany, France, Italy and the UK have started to extract battery-grade lithium from existing and new geothermal capacity.
- **An enabler of the socially inclusive energy transition:** The geothermal electricity plants in Radicondoli (Tuscany, Italy) will reimburse 30% of electricity costs from local geothermal power plants. This comes from the royalties from geothermal power production and could be replicated in other regions with geothermal power or geothermal power combined with district heating systems.
- **Vital to manage cooling load:** Cooling is a growing problem for electricity systems due to climate change and urban heat networks. Distribution System Operators (DSOs) are turning to geothermal cooling networks to take the load off the power system. **Stadtwerke Munchen**, the energy utility owned by Munich's local government, invested in communal cooling network in the Sendling district to reduce the electricity consumption linked to cooling by 70% across its 22 km grid. This must be replicated across Europe and incentivised in two-way CfDs.
- **Flexibility:** Geothermal Power plants in Germany are required to demonstrate their flexibility services to the grid. These demonstrations indicate that production can be scaled down and ramped up in 15 seconds.
- **Cheapest form of storage:** Geothermal provides thermal storage at lower system costs than renewables with other storage technologies. IRENA's report on Thermal Energy Storage (2020) mentioned underground thermal energy storage costs in the range of 0.1 to 35 USD/kWh, which is the cheapest of all storage options. Furthermore, Holmes et al, *"Multilateral Closed-Loop Geothermal Systems as a Zero-Emission Load Following Resource,"* (GRC Transactions vol 45, 2021) demonstrated that geothermal storage with 90GW of the Eavor-Loop™ would replace an additional 200 GW of capacity to meet a 110 GW demand and save 9,000 km^2 of land for other purposes.

1.2 Policy recommendations

Geothermal needs the following from the Electricity Market Design….

1. **A tendering system that rewards its multiple benefits.**
   The proposed two-way CfD rules to tender new capacity (Article 19b) must include **non-price services** such as system adequacy, reliability, storage and flexibility as well as additional services such as heating, cooling, sustainable lithium or other raw material extraction into strike prices to sufficiently reward and incentivise investment in geothermal capacity.
   It is unlikely that new geothermal electricity capacity will be secured through the proposed two-way CfDs without strike prices including these essential non-price features. New geothermal capacity will not be commissioned solely to provide storage or flexibility alone because the Levelised Cost of Energy (LCOE) for geothermal includes these services, which explains why the upfront CAPEX cost is higher. In Italy, a 15 MW_e geothermal plant had a capital cost of €103 million LCOE; compared to €68 million for a 39.6 MW_e geothermal plant; whilst 10 and 20 MW_e of onshore wind had LCOEs of €59 million and €52 million, according to the IEA's LCOE Calculator.
   Some auctions in Europe have failed or were cancelled due to a lack of bidders because strike prices did not account for inflated cost of materials and labour. Failures such as these must not be an option if we are to protect citizens and industry from fossil powered energy. Hence the need to ensure these variables are also included in the tendering process.
   Finally, it is important to incentivise new power capacity that is not dependent on the use of critical raw materials and uses local supply chains for materials, labour and expertise. This criteria was taken from an earlier version of the European Commission's proposal and transferred to the Net-Zero Industry Act. This basis must be included back into the EMD with clear definitions of sustainability and resilience.

2. **Integrating renewable generation into the assessments and support schemes to reward storage and flexibility.**
   The Commission's proposal excludes renewable generation capacity (geothermal, solar thermal power, oceans, and hydro) from the storage and flexibility assessments and tenders. They are the cost-solutions to these services and require support, preferably through capacity mechanisms, or new instruments as highlighted in Article 19f.
   Existing geothermal capacity should receive financial rewards for these services through these tendering mechanisms. However, new capacity will not be built just to provide these services. Instead, new geothermal capacity, which also provides flexibility and storage must be incentivised as a package of measures through two-way CfDs that include these services in the strike price.

Main take-aways

1. Geothermal electricity has been around for over a century offering a consistent and flexible source of renewable electricity.
2. The EU has over 1 GW of geothermal energy capacity but needs to significantly increase it to meet climate and energy targets.
3. Geothermal power provides benefits like grid stability, thermal storage, and flexible generation.
4. Geothermal electricity is generated through binary cycle power plants and steam power plants, with excess heat being used in cogeneration systems.
5. Recent interest in geothermal energy is driven by the need for stable and secure power supply, making it a valuable component in the EU's electricity market design.

1.3 Policy factsheets

GEOSMART Factsheet: geothermal and the energy price crisis

- **PUBLISHED**: April 8, 2022

At the beginning of summer 2021, gas prices started increasing tremendously globally due to a wide array of factors, from an exceptionally cold winter in Europe in 2020, to macroeconomic fallouts of the COVID 19 pandemic, without mentioning geopolitics, to technical issues in infrastructure bottlenecks of the fossil fuel production infrastructure.

As a result, gas prices shot up on the European spot market from 5-10 €/MWh in 2019-2020 to 50 €/MWh in September 2021. However, the story does not end here and will continue inn 2022.

This crisis is not just and "energy price crisis": geothermal power plants are not more expensive to build and operate. Geothermal district heating and cooling prices did not increase several times over.

Geothermal technologies provide many different types of benefits to the electricity system beyond the simple operation of a flexible electricity generator.

This factsheet, developed in the framework of the GEOSMART project, explores the pathways for geothermal to contribute to solving the energy price crisis.

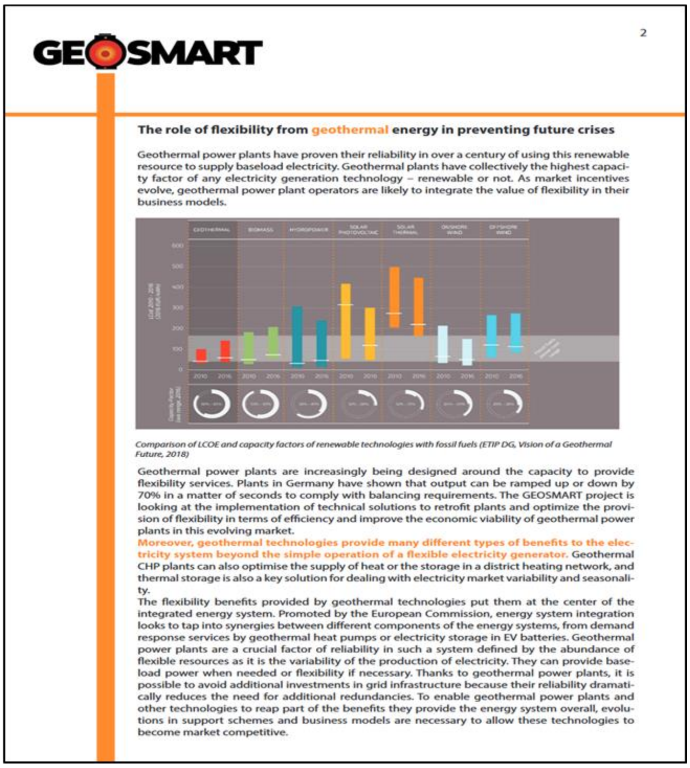
GEOSMART

Energy Prices: the geothermal answer

The 2021/2022 high energy prices, and security of energy supply crisis

At the beginning of summer 2021, gas prices started increasing tremendously globally due to a wide array of factors, from an exceptionally cold winter in Europe in 2020, to macroeconomic fallouts of the COVID 19 pandemic, without mentioning geopolitics, to technical issues in infrastructure bottlenecks of the fossil fuel production infrastructure. As a result, gas prices shot up on the European spot market from 5-10 €/MWh in 2019-2020 to 50 €/MWh in September 2021. However, the story does not end here and will continue inn 2022. In much of the European electricity market, gas power plants remain the main providers of flexibility and, as such, have an outsized impact on the price of electricity during supply crunches . Electricity prices on the European spot market shot up from 30-50 €/MWh in 2020 to 150-200 €/MWh in the summer of 2021, with spikes as high as 300€/MWh . In February 2022, following the invasion of Ukraine by Russia – which are respectively a key gas pipeline hub and the largest supplier of fossil fuels to Europe – prices spiked further , deepening the crisis and pushing the European Commission to come up with the RePowerEU communication to present new tools for reducing the exposure of the EU economy to Russian fossil fuel imports. Moreover, many voices have been calling for a revision of the EU electricity market framework – on the margin or at its core – to better incentivize investment in flexibility resources, notably from renewable technologies.

This crisis is not just and "energy price crisis": geothermal power plants are not more expensive to build and operate. Geothermal district heating and cooling prices did not increase several times over. This is a gas price crisis, which is the result of a series of policy decisions taken by the EU and Member States.
The 2021/2022 energy price crisis highlights the vulnerability of the global fossil fuel supply chain and how vulnerable European citizens and businesses are to such events. **This crisis is also a warning when the European Commission is deploying the European Green Deal.** While European countries are laying up their Recovery plans, it is an opportunity to plan the infrastructure of the energy system around the provision of flexibility from renewables for greater resilience to the upcoming supply crisis.



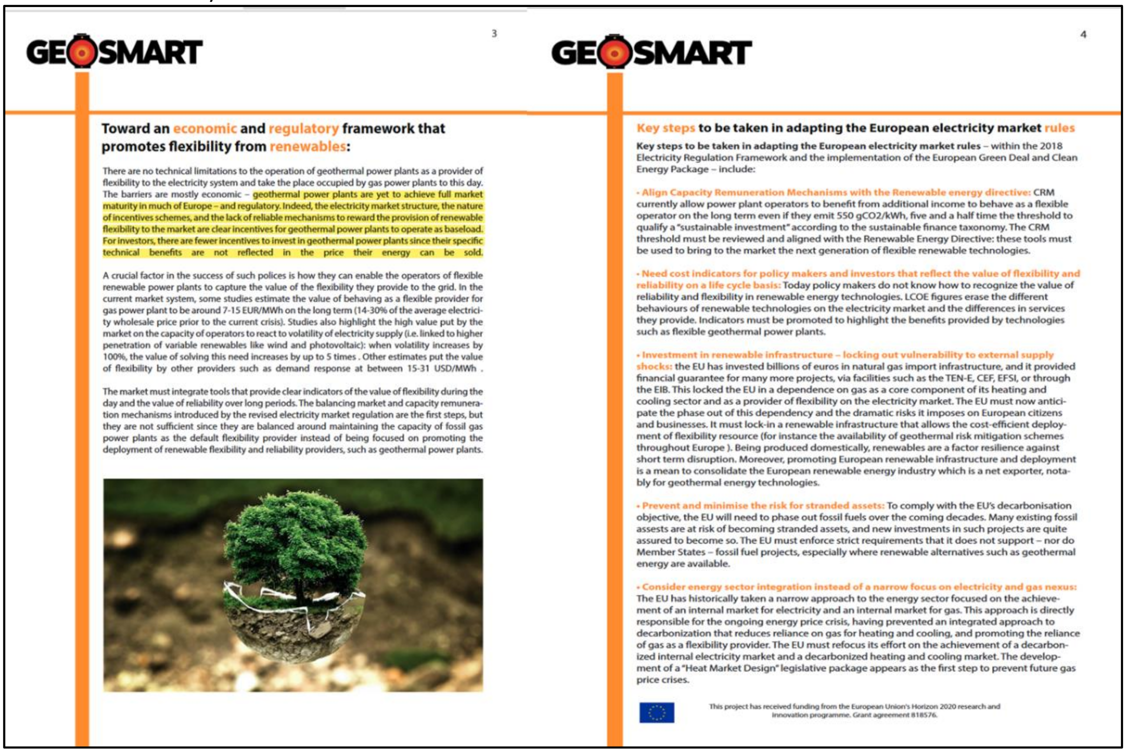
GEOSMART 2

The role of flexibility from geothermal energy in preventing future crises

Geothermal power plants have proven their reliability in over a century of using this renewable resource to supply baseload electricity. Geothermal plants have collectively the highest capacity factor of any electricity generation technology – renewable or not. As market incentives evolve, geothermal power plant operators are likely to integrate the value of flexibility in their business models.

Comparison of LCOE and capacity factors of renewable technologies with fossil fuels (ETIP DG, Vision of a Geothermal Future, 2018)

Geothermal power plants are increasingly being designed around the capacity to provide flexibility services. Plants in Germany have shown that output can be ramped up or down by 70% in a matter of seconds to comply with balancing requirements. The GEOSMART project is looking at the implementation of technical solutions to retrofit plants and optimize the provision of flexibility in terms of efficiency and improve the economic viability of geothermal power plants in this evolving market.
Moreover, geothermal technologies provide many different types of benefits to the electricity system beyond the simple operation of a flexible electricity generator. Geothermal CHP plants can also optimise the supply of heat or the storage in a district heating network, and thermal storage is also a key solution for dealing with electricity market variability and seasonality.
The flexibility benefits provided by geothermal technologies put them at the center of the integrated energy system. Promoted by the European Commission, energy system integration looks to tap into synergies between different components of the energy systems, from demand response services by geothermal heat pumps or electricity storage in EV batteries. Geothermal power plants are a crucial factor of reliability in such a system defined by the abundance of flexible resources as it is the variability of the production of electricity. They can provide baseload power when needed or flexibility if necessary. Thanks to geothermal power plants, it is possible to avoid additional investments in grid infrastructure because their reliability dramatically reduces the need for additional redundancies. To enable geothermal power plants and other technologies to reap part of the benefits they provide the energy system overall, evolutions in support schemes and business models are necessary to allow these technologies to become market competitive.



GEOSMART

3

Toward an economic and regulatory framework that promotes flexibility from renewables:

There are no technical limitations to the operation of geothermal power plants as a provider of flexibility to the electricity system and take the place occupied by gas power plants to this day. The barriers are mostly economic – geothermal power plants are yet to achieve full market maturity in much of Europe – and regulatory. Indeed, the electricity market structure, the nature of incentives schemes, and the lack of reliable mechanisms to reward the provision of renewable flexibility to the market are clear incentives for geothermal power plants to operate as baseload. For investors, there are fewer incentives to invest in geothermal power plants since their specific technical benefits are not reflected in the price their energy can be sold.

A crucial factor in the success of such polices is how they can enable the operators of flexible renewable power plants to capture the value of the flexibility they provide to the grid. In the current market system, some studies estimate the value of behaving as a flexible provider for gas power plant to be around 7-15 EUR/MWh on the long term (14-30% of the average electricity wholesale price prior to the current crisis). Studies also highlight the high value put by the market on the capacity of operators to react to volatility of electricity supply (i.e. linked to higher penetration of variable renewables like wind and photovoltaic): when volatility increases by 100%, the value of solving this need increases by up to 5 times . Other estimates put the value of flexibility by other providers such as demand response at between 15-31 USD/MWh .

The market must integrate tools that provide clear indicators of the value of flexibility during the day and the value of reliability over long periods. The balancing market and capacity remuneration mechanisms introduced by the revised electricity market regulation are the first steps, but they are not sufficient since they are balanced around maintaining the capacity of fossil gas power plants as the default flexibility provider instead of being focused on promoting the deployment of renewable flexibility and reliability providers, such as geothermal power plants.

GEOSMART

4

Key steps to be taken in adapting the European electricity market rules

Key steps to be taken in adapting the European electricity market rules – within the 2018 Electricity Regulation Framework and the implementation of the European Green Deal and Clean Energy Package – include:

- **Align Capacity Remuneration Mechanisms with the Renewable energy directive:** CRM currently allow power plant operators to benefit from additional income to behave as a flexible operator on the long term even if they emit 550 gCO2/kWh, five and a half time the threshold to qualify a "sustainable investment" according to the sustainable finance taxonomy. The CRM threshold must be reviewed and aligned with the Renewable Energy Directive: these tools must be used to bring to the market the next generation of flexible renewable technologies.

- **Need cost indicators for policy makers and investors that reflect the value of flexibility and reliability on a life cycle basis:** Today policy makers do not know how to recognize the value of reliability and flexibility in renewable energy technologies. LCOE figures erase the different behaviours of renewable technologies on the electricity market and the differences in services they provide. Indicators must be promoted to highlight the benefits provided by technologies such as flexible geothermal power plants.

- **Investment in renewable infrastructure – locking out vulnerability to external supply shocks:** the EU has invested billions of euros in natural gas import infrastructure, and it provided financial guarantee for many more projects, via facilities such as the TEN-E, CEF, EFSI, or through the EIB. This locked the EU in a dependence on gas as a core component of its heating and cooling sector and as a provider of flexibility on the electricity market. The EU must now anticipate the phase out of this dependency and the dramatic risks it imposes on European citizens and businesses. It must lock-in a renewable infrastructure that allows the cost-efficient deployment of flexibility resource (for instance the availability of geothermal risk mitigation schemes throughout Europe). Being produced domestically, renewables are a factor resilience against short term disruption. Moreover, promoting European renewable infrastructure and deployment is a mean to consolidate the European renewable energy industry which is a net exporter, notably for geothermal energy technologies.

- **Prevent and minimise the risk for stranded assets:** To comply with the EU's decarbonisation objective, the EU will need to phase out fossil fuels over the coming decades. Many existing fossil assests are at risk of becoming stranded assets, and new investments in such projects are quite assured to become so. The EU must enforce strict requirements that it does not support – nor do Member States – fossil fuel projects, especially where renewable alternatives such as geothermal energy are available.

- **Consider energy sector integration instead of a narrow focus on electricity and gas nexus:** The EU has historically taken a narrow approach to the energy sector focused on the achievement of an internal market for electricity and an internal market for gas. This approach is directly responsible for the ongoing energy price crisis, having prevented an integrated approach to decarbonization that reduces reliance on gas for heating and cooling, and promoting the reliance of gas as a flexibility provider. The EU must refocus its effort on the achievement of a decarbonized internal electricity market and a decarbonized heating and cooling market. The development of a "Heat Market Design" legislative package appears as the first step to prevent future gas price crises.

This project has received funding from the European Union's Horizon 2020 research and innovation programme. Grant agreement 818576.

GeoSmart and the European Electricity Market

- **PUBLISHED:** Wed, 15 December, 2021

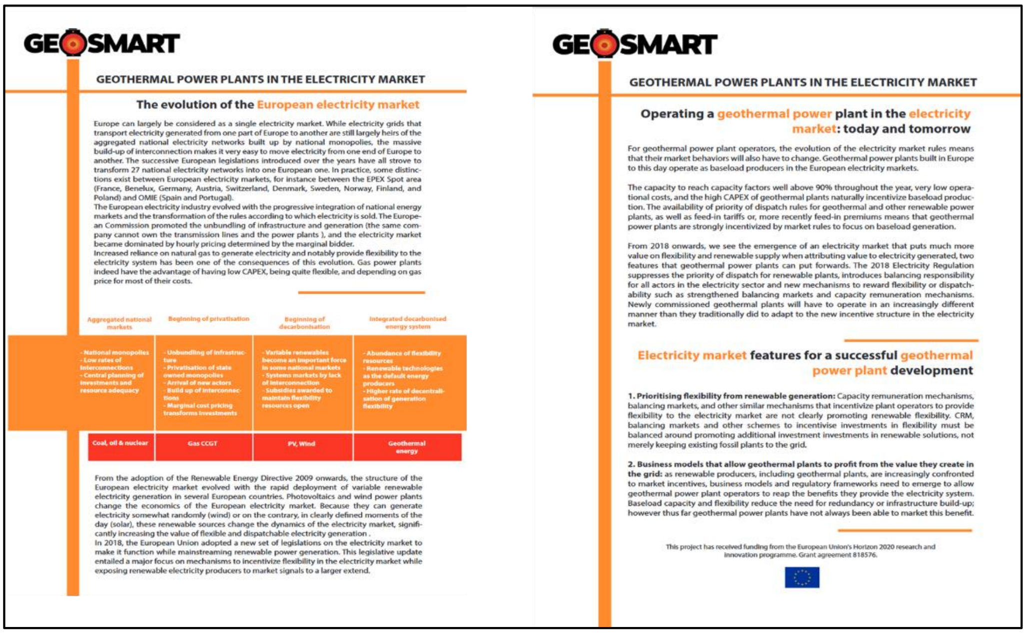
The GeoSmart project consortium has produced a document investigating how geothermal power plants connect to the European electricity market.

Including how national electricity monopolies have been joined together to create a Europe-wide electricity grid structure, the document details how geothermal works alongside coal, oil, nuclear, gas, and renewable sources to create a wider energy mix.

As an electricity market that puts more value on flexibility and renewable emerges, geothermal power plants not only offer a solution to these emerging trends but should also profit from the value they create in the continental electricity grid.

See the PDF, below for more:

[Factsheet geothermal in the electricity market - pdf - 655kb]



GEOSMART

GEOTHERMAL POWER PLANTS IN THE ELECTRICITY MARKET

The evolution of the European electricity market

Europe can largely be considered as a single electricity market. While electricity grids that transport electricity generated from one part of Europe to another are still largely heirs of the aggregated national electricity networks built up by national monopolies, the massive build-up of interconnection makes it very easy to move electricity from one end of Europe to another. The successive European legislations introduced over the years have all strove to transform 27 national electricity networks into one European one. In practice, some distinctions exist between European electricity markets, for instance between the EPEX Spot area (France, Benelux, Germany, Austria, Switzerland, Denmark, Sweden, Norway, Finland, and Poland) and OMIE (Spain and Portugal).

The European electricity industry evolved with the progressive integration of national energy markets and the transformation of the rules according to which electricity is sold. The European Commission promoted the unbundling of infrastructure and generation (the same company cannot own the transmission lines and the power plants), and the electricity market became dominated by hourly pricing determined by the marginal bidder.

Increased reliance on natural gas to generate electricity and notably provide flexibility to the electricity system has been one of the consequences of this evolution. Gas power plants indeed have the advantage of having low CAPEX, being quite flexible, and depending on gas price for most of their costs.

Aggregated national markets	Beginning of privatisation	Beginning of decarbonisation	Integrated decarbonised energy system
- National monopolies - Low rates of interconnections - Central planning of investments and resource adequacy	- Unbundling of infrastructure - Privatisation of state owned monopolies - Arrival of new actors - Build up of interconnections - Marginal cost pricing transforms investments	- Variable renewables become an important force in some national markets - Systems markets by lack of interconnection - Subsidies awarded to maintain flexibility resources open	- Abundance of flexibility resources - Renewable technologies as the default energy producers - Higher rate of decentralisation of generation flexibility
Coal, oil & nuclear	Gas CCGT	PV, Wind	Geothermal energy

From the adoption of the Renewable Energy Directive 2009 onwards, the structure of the European electricity market evolved with the rapid deployment of variable renewable electricity generation in several European countries. Photovoltaics and wind power plants change the economics of the European electricity market. Because they can generate electricity somewhat randomly (wind) or on the contrary, in clearly defined moments of the day (solar), these renewable sources change the dynamics of the electricity market, significantly increasing the value of flexible and dispatchable electricity generation .

In 2018, the European Union adopted a new set of legislations on the electricity market to make it function while mainstreaming renewable power generation. This legislative update entailed a major focus on mechanisms to incentivize flexibility in the electricity market while exposing renewable electricity producers to market signals to a larger extend.

GEOSMART

GEOTHERMAL POWER PLANTS IN THE ELECTRICITY MARKET

Operating a geothermal power plant in the electricity market: today and tomorrow

For geothermal power plant operators, the evolution of the electricity market rules means that their market behaviors will also have to change. Geothermal power plants built in Europe to this day operate as baseload producers in the European electricity markets.

The capacity to reach capacity factors well above 90% throughout the year, very low operational costs, and the high CAPEX of geothermal plants naturally incentivize baseload production. The availability of priority of dispatch rules for geothermal and other renewable power plants, as well as feed-in tariffs or, more recently feed-in premiums means that geothermal power plants are strongly incentivized by market rules to focus on baseload generation.

From 2018 onwards, we see the emergence of an electricity market that puts much more value on flexibility and renewable supply when attributing value to electricity generated, two features that geothermal power plants can put forwards. The 2018 Electricity Regulation suppresses the priority of dispatch for renewable plants, introduces balancing responsibility for all actors in the electricity sector and new mechanisms to reward flexibility or dispatchability such as strengthened balancing markets and capacity remuneration mechanisms. Newly commissioned geothermal plants will have to operate in an increasingly different manner than they traditionally did to adapt to the new incentive structure in the electricity market.

Electricity market features for a successful geothermal power plant development

1. Prioritising flexibility from renewable generation: Capacity remuneration mechanisms, balancing markets, and other similar mechanisms that incentivize plant operators to provide flexibility to the electricity market are not clearly promoting renewable flexibility. CRM, balancing markets and other schemes to incentivise investments in flexibility must be balanced around promoting additional investment investments in renewable solutions, not merely keeping existing fossil plants to the grid.

2. Business models that allow geothermal plants to profit from the value they create in the grid: as renewable producers, including geothermal plants, are increasingly confronted to market incentives, business models and regulatory frameworks need to emerge to allow geothermal power plant operators to reap the benefits they provide the electricity system. Baseload capacity and flexibility reduce the need for redundancy or infrastructure build-up; however thus far geothermal power plants have not always been able to market this benefit.

This project has received funding from the European Union's Horizon 2020 research and innovation programme. Grant agreement 818576.

2. CHAPTER 2 – LIAISON

2.1 Mapping task of national stakeholders

Italian stakeholders mapping

The stakeholder mapping exercise for Italy identified 102 subjects belonging to different groups. The group with the largest number of stakeholders is Group 1, since it also includes project developers and engineering companies that may have similar interests of operators towards the GeoSmart technologies. Although the geothermal sector is not growing in Italy in recent years, there is a long lasting research tradition, both in geology and geophysics and in engineering topics, with many research groups involved in geothermal, in research centres and universities in Italy. Similarly, the geothermal supply chain is well developed in Italy and it accounts for many manufacturers of different geothermal plant components. Most of these companies are satellite activities of Enel Green Power, in geothermal areas in Tuscany.

Many associations deal with geothermal energy. These are industry associations, but also environmental associations, networks of citizens for the promotion of geothermal energy, or opposing it.

Compared to the original classification proposed by the GeoSmart project, a seventh group has been added for grid operators. These subjects are not linked to geothermal energy, but they may be interested in the development and implementation of the flexible technologies proposed by GeoSmart, increasing the dispatching capacity of the networks they manage. One operator identified is *Terna*, which takes care of the transmission network, while the other, *e-distribuzione*, manages the distribution networks in much of Italy.

Despite this large number of stakeholders in Italy, in several cases, it was not possible to reach them.

Table 1 Relevant stakeholders in the Italian geothermal energy sector

Group	Group Categorization	# of Stakeholders
Group 1	Ultimate end users and beneficiaries (it also includes project developers and engineering companies)	38
Group 2	Optional end users	4
Group 3	Manufacturers	17
Group 4	Primary influential bodies/industry association	16
Group 5	Investors	0
Group 6	Academia	25
Group 7	Grid operators	2

Despite the large number of subjects identified, it has been challenging to contact them to disseminate and communicate the GeoSmart project. This is due to two main reasons: many companies work in the geothermal sector, but they are very small and work exclusively for Enel Green Power, while it was not possible to find the contacts of some operators.

Turkish stakeholders mapping

Before organizing a national forum, METU conducted a stakeholder analysis to determine the most relevant partners in the Turkish geothermal energy sector. The 56 stakeholders were chosen from different groups with different numbers, as listed in Table 2.

Table 2 Relevant stakeholders in the Turkish geothermal energy sector

Group	Group Categorization	# of Stakeholders
Group 1	Ultimate end users and beneficiaries	17
Group 2	Optional end users	2

Group	Group Categorization	# of Stakeholders
Group 3	Manufacturers	4
Group 4	Primary influential bodies/industry association	17
Group 5	Investors	3
Group 6	Academia	13

To apply a "Power and Interest" analysis, firstly, stakeholders were rated based on five variables: willingness to engage as an indicator of "***Interest"*** and contribution, legitimacy, influence, and the necessity to involvement as an indicator of "***Power."*** Then, *the* ***Power and Interest*** scheme in Figure 1 is constructed based on these indicators.

Considering the power and interest indicators, the importance of stakeholders was revealed for the natural forum that would be organized. As seen in Figure 1, some stakeholders, with their degrees of high interest and high power, were found to be critical to interview. Indeed, these partners play a crucial role in developing the Turkish geothermal energy sector. The partners, with their degrees of high interest but relatively low power, could be the potential stakeholders who could be very helpful in acquiring some details in the geothermal sector. On the other hand, interviewing the partners with low interest but high power was again valuable in gaining insight into their dominance in the industry. The partners, with their low degrees of interest and power, could be omitted from the potential stakeholder list, or some can be added to get unusual information. In light of all these evaluations, METU finally selected 15 participants from different fields of the geothermal energy sector for the national forum that would be organized.

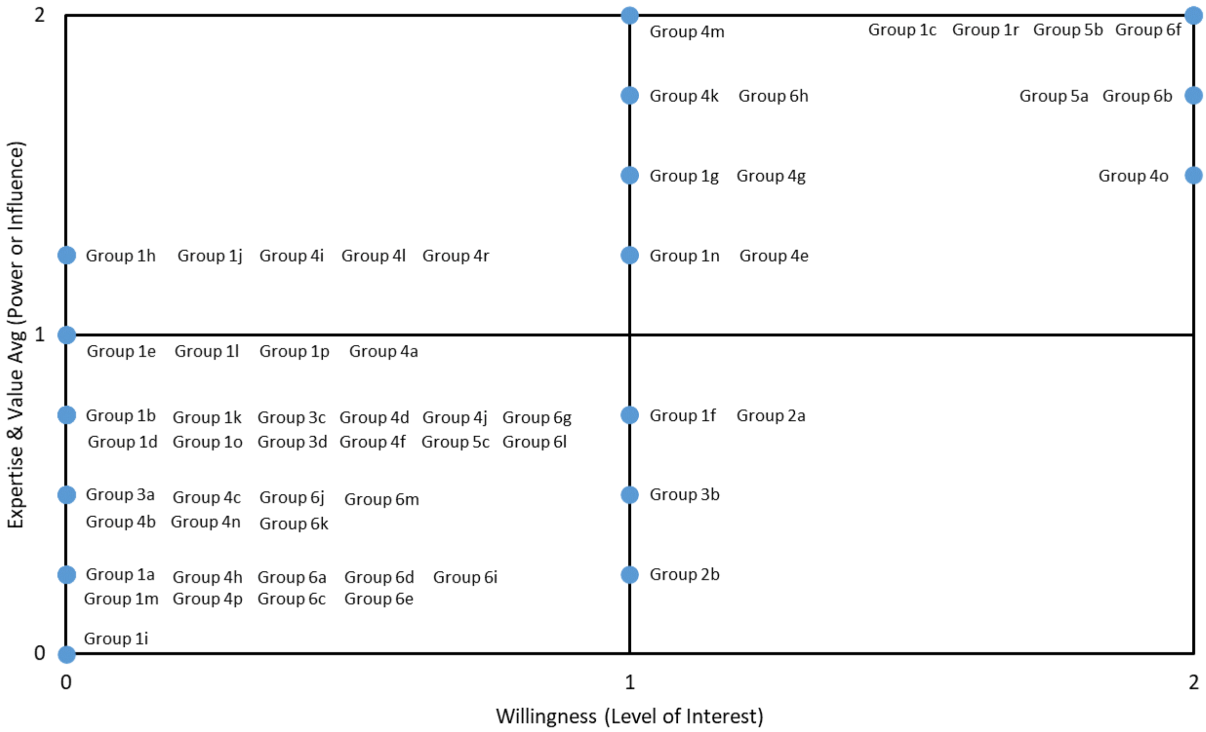


Figure 1 Power and Interest Scheme on Turkish Stakeholder Mapping

Iceland Stakeholders mapping

The Icelandic geothermal stakeholders were mapped and interviewed about their perspectives on geothermal challenges and smart geothermal energy generation opportunities. 17 out of 31 of the mapped stakeholders were interviewed and invited to a workshop/forum which will be held alongside the Icelandic Geothermal Congress of 2024 in Reykjavík. The 31 stakeholders chosen were divided into 7 groups based on their activities, as seen in Table 3 below.

Table 3 Relevant stakeholders in the Icelandic geothermal energy sector

Group	Group Categorization	# of Stakeholders
Group 1	Ultimate end users and beneficiaries	11
Group 2	Optional end users	1
Group 3	Manufacturers	4
Group 4	Primary influential bodies/industry association	4
Group 5	Investors	5
Group 6	Academia	4
Group 7	Grid operators	2

Belgian Stakeholders mapping

The Belgium geothermal stakeholders were mapped. 7 out of 69 of the mapped stakeholders were interviewed about their perspectives on geothermal challenges and smart geothermal energy generation opportunities. The 69 stakeholders identified belong to 6 of the 7 groups already mentioned in the three other countries. The stakeholder group categories and number of stakeholders in each of them are summarized in Table 4. The interviews covered stakeholders of the group 1, 5 and 6.

Table 4 Stakeholder group interviews

Group	Group Categorization	# of Stakeholders
Group 1	Ultimate end users and beneficiaries	12
Group 3	Manufacturers	18
Group 4	Primary influential bodies/industry association	10
Group 5	Investors / supporters	9
Group 6	Academia and Public	9
Group 7	Grid operators/ Distribution	11

2.2 Feedback from national fora

Italian National Forum

COSVIG (Consortium for the Development of Geothermal Areas), with the contribution of the Regional Council of Tuscany, organized a panel meeting in Florence on June the 22nd 2023, which was attended by the Italian Geothermal Association (UGI - Italian Geothermal Union), consultancies and operators and the GeoSmart partners. The aim of the meeting was to discuss and understand the impact of the project innovations in addressing the challenges that the Italian geothermal industry is facing in the context of resource management.

The two GeoSmart Italian partners COSVIG and Spike Renewables started the meeting and introduced geothermal energy in Tuscany. This was followed by TWI, which provided an overview on the GeoSmart project and other geothermal initiatives. The description of the innovations being installed in Kizildere 2 (Turkey), was covered by Zorlu Energy, while information about the second demo site, the binary plant of Insheim (Germany), was presented by Natürlich Insheim, who deepened lessons learned in mitigating the scaling and corrosion phenomena. They also presented the challenges and expectations of technologies that will increase the flexibility of these plants, through different thermal energy storages. CEA focused on presenting on high temperature thermal energy storage, to improve the flexibility of the two demo sites in providing heat and power. Solutions related to the silicate scaling reduction being implemented in Kizildere 2 were presented by Spike Renewables. This system will reduce the use of scaling inhibitors and, at the same time, it will allow the recovery of more heat from geothermal brines upstream of the reinjection and recover silica that can be sold in the market.

Reykjavik Energy (OR and ON) closed the presentations of the GeoSmart partners with a presentation on the Icelandic experiences related to challenges for the management of supercritical geothermal resources. This issue launched the new Horizon Europe COMPASS project, which also addresses key aspects common to GeoSmart, including studies on materials and mitigation of scaling and corrosion.

The afternoon session was dedicated to interventions from Italian stakeholders: UGI presented the main barriers to the geothermal development in Italy, such as non-technical barriers like environmental concerns, the 'NIMBY' (not in my backyard) syndrome, bureaucracy, long-lasting authorisation processes and a lack of incentives. Enel Green Power, one of the world's leading geothermal operators, reported their experiences in managing plants and the production of power and heat, whereas the other participating operator, Sorgenia Geothermal, described the challenges for the development of the binary plants in Tuscany, with a focus on their most advanced project, the Val di Paglia power plant. The consultancy and project developer Steam reported its experiences in mineral extraction from geothermal brines and management of fluids with high silicate contents, through a system designed by them and built in plants in Asia and Central America.

The meeting was concluded by an open debate among participants to discuss on how the GeoSmart innovations can help stakeholders in facing challenges linked to the use of fluids. The innovative solutions presented in this meeting can contribute to expanding the use of geothermal systems, making the systems increasingly efficient and the exploitation of the geothermal resource more sustainable.

Turkish National Forum

GeoSmart partner METU (Middle East Technical University) held an online Eastern European calling interview session with geothermal stakeholders on 28 September 2021 in Turkey. Fifteen experts from different fields of the geothermal sector, *e.g., academia, research centres, private sector, development banks, investors, and consultancy firms*, attended the calling Interview to share their expertise and experience.

The attendees were asked to share their opinions on the questions prepared by METU, reflecting the socio-economic and technical aspects of GeoSmart, which would be used in one-to-one interviews with critical geothermal actors in the future. The purpose of the organized calling interview was to identify and clarify the right questions during the individual interviews based on the feedback from these key experts.

The highlights of the discussed topics during the organized meeting are listed below:

- Lack of public awareness and acceptance despite Turkey's breaking into the Top 5 in terms of installed capacity (*#4 in the world, #1 in the Europe)*
- Underutilization of R&D opportunities considering installed state-of-the-art power plants, e*g., Turkey hosts 3 of the five triple-flash geothermal power plants in the world with minimal R&D effort in developing these technologies*
- Requirement of collaboration between universities and university-industry cooperation
- Suggestions regarding reservoir management and licensing
- Competition and state of geothermal to other renewables, *e., wind and solar PV*
- Current state and projections of geothermal electricity in Turkey's energy mix
- Importance of inclusiveness and holistic approach in the utilization of geothermal energy to consider the greenhouses, district heating, and hybridization opportunities.

All participants agreed on the country's geothermal potential and the importance of geothermal as a renewable, domestic, and base-load energy source. On the other hand, many of them emphasized that the rapid growth of the geothermal generation sector in the last five years led to numerous social and technical challenges. The small firms entering the industry in pursuit of profits were strongly criticized for their lack of social and environmental awareness. Their improper reinjection applications and their attitudes disregarding the importance of public participation were found to be the main reasons for the rising social resistance to geothermal. The interviewees also pointed out that the lack of cooperation between the universities and the industry posed an obstacle to developing new technologies and R&D studies. They stressed that Turkey should be capable of producing its technology as a leading country in geothermal energy.

In the meeting, the reservoir management problems, along with poorly managed licensing procedures, were also discussed. The participants indicated that unconscious use of the same reservoir ("not optimum but maximum") and improper reinjection applications threaten resource sustainability today. Some of them expressed that the decrease in the capacity factors would become more noticeable over the next five years, potentially affecting power generation and the profitability of plant operators. Starting from the necessity of systematic monitoring mechanisms, they offered to establish an independent institution for regulating and monitoring renewable energy sources, including geothermal.

The participants also agreed on the importance of integrated systems with electricity generation for both firms' profitability and public benefits, thus the increasing social acceptance of geothermal energy. They emphasized that direct-use applications should also be incentivized and lead investors to other potential but less operated fields. While regarding the hybridization of geothermal with other renewables as a significant development, they insisted on the necessity of further legislation in this field. The interviewees evaluating the GeoSmart innovations as promising emphasized the importance of revealing their costs in terms of investors.

Lastly, before the meeting ended, the participants offered some other critical stakeholders to conduct interviews, such as geothermal associations (JED and JESDER), regional NGOs, municipalities, and authorities at the Renewable Energy Department of the Ministry of Energy, and the officials from the General Directorate of Mineral Research and Exploration (MTA).

2.3 Feedback from two European capacity building exercises

Two capacity building events were organised to convey the main findings of the GeoSmart project and to allow for knowledge transfer among stakeholders for improving the market uptake of geothermal. They focused on business models and flexible technologies respectively.

Geothermal power for a smart electricity market & grids

To present and discuss flexible technologies, on 1 December 2023, the public webinar *Geothermal power for a smart electricity market & grids* was organised by the GeoSmart project team. It presented the initial findings from the GeoSmart project followed by in-depth discussions around electricity market design policies for geothermal and geothermal flexible technologies for a smart electricity grid. The online event included presentations by experts from TWI, EGEC, COSVIG, Fraunhofer, METU, and VITO.

In this webinar, the speakers presented an insightful exploration of the GEOSMART project's initial findings, followed by in-depth discussions on Electricity Market design policies for Geothermal and Geothermal flexible technologies to a smart electricity grid. This webinar provided the participants with valuable insights into EU policies, market competitiveness, and innovative solutions driving the future of geothermal energy. This dynamic event fostered collaboration and knowledge exchange in the geothermal sector.

Presentations are available below :

10:30 Welcome

10:30 – 10:40 GEOSMART first project results, *TWI, Namrata Kale*

10:40 – 11:15 Session 1: Electricity Market Design Policies for Geothermal

- Updates on EU policies for geothermal power, *EGEC, Sanjeev Kumar*
- Market and Competitiveness of geothermal technologies, *EGEC, Emil Martini*
- Case of Italy, *COSVIG, Dario Bonciani*

11:15 – 11:50 Session 2: Geothermal flexible technologies

- GEOSMART flexible solutions, *Fraunhofer, Shahab Rohani*
- Geothermal hybrid energy plant opportunities, *METU, Bertuğ Celebi*
- Case of Belgium, *VITO, Wilfried Bero*

11:50 – 12:00 Q&A and Conclusions

The European Union adopted a set of laws regarding the electricity market which provided for strongly encouraging flexibility in electricity production from renewable sources in 2018[2]. Geothermal is a constant and reliable energy source that can provide electricity 24/7 and it currently mainly meets the grid's baseload needs. Despite this, it can contribute to the dispatchability of the transmission grids and investments on a more flexible production are necessary with mechanisms promoting flexible renewable energy sources. Indeed, geothermal systems are increasingly designed to provide flexible services. For example, in Germany it has been shown that plants can increase up to 30% or reduce their production by up to 70%, in response to fluctuations in demand,

[2] Factsheet GEOSMART: Geothermal Power Plants in the Electricity Market

in few seconds[3]. Geothermal cogeneration (CHP) plants can optimize the heat supply in a district heating network, whereas thermal storages of geothermal heat are also key solution to address the market variability and seasonality.

GeoSmart aims to design and implement technical solutions to make existing geothermal plants more flexible and efficient with economically viable solutions. Since the optimal working conditions highly depend on the fluid characteristics and the users demands, CHP geothermal systems are designed to extract heat from the fluid at different temperature levels, with for example cascaded ORC cycles or extraction for cooling. To increase the flexibility of this type of system, there is an increasing tendency to try to decouple the production of electricity from the production of heat. The most promising developments in this framework are both mechanical plant optimization, such as multistage turbines to increase efficiency of the ORC, lower reinjection temperature, the installation of large heat pump systems to extend thermal performances of CHP plants (ETIP – G, 2023) and the use of heat storage. In particular, the thermal storages with tanks and Underground Thermal Energy Storages (UTES) allow a considerable increase in flexibility over time and can be applied either in the short term (addressing daily fluctuations in demand) or in the long term (addressing seasonal or annual fluctuations), contributing to the phase out from fossil fuels of the electricity and the heating and cooling sectors. This method offers the opportunity to integrate different renewable sources in the same heating circuit (wind, solar and geothermal), furthermore it is competitive from an economic point of view and can be applied in case of a decentralized energy system. UTES can also be used to store surpluses of electricity production, or the excess energy produced as heat and even low temperature UTES systems can store high amounts of heat (ETIP – G, 2023).

The possibility of combining geothermal energy with other renewable sources (biomass or solar) is being evaluated as a solution to improve efficiency and flexibility of systems and the hybridization can help to convert weakness into strengths. For example, the efficiency of geothermal power plants drops during hot summer months, while the solar insolation is at maximum. The effects of seasonal temperature variations can be reduced hybridising geothermal with concentrated solar thermal system. GeoSmart is exploring the potential of hybridization of high enthalpy geothermal plants: for the plant at the Kizildere I site the hybridization between geothermal energy and biomass was tested using a locally available biomass source, olive residue[4]. In the case of the Kizildere II plant, hybridization of geothermal with concentrated solar energy (CSP) was modelled[5]. According to what was reported by stakeholders in the interviews conducted for the GeoSmart consortium, the higher flexibility of the systems should be recognized with adequate policies and rewards for both the sustainability of the energy source used and its capability of stabilizing energy networks.

[3] Factsheet GEOSMART: Energy Prices: the geothermal answer

[4] Blog on GeoSmart project website: “GeoSmart explores Hybridization of Geothermal with Biomass”, 2020

[5] Webinar on GeoSmart project website: “Hybridization of Geothermal with Biomass and Concentrated Solar Thermal”, 2023

Business models for geothermal heat and power projects

A collaborative physical activity on business models was organised as part of the Geothermal District Heating and Cooling Days 2023, 19-21 September in Aarhus, Denmark with the SAPHEA project. The three-day event was attended by over 100 participants from industry experts and researchers to other stakeholders. An international workshop on *Business and financing models for geothermal energy-supplied heating (and cooling) networks in Europe* took place on the first day addressing three key aspects: (1) Financing, de-risking and Business Models, (2) Data availability and Technologies, and (3) Regulatory, Acceptance and values.

In Europe, the energy sector is seeing a revolution due to policy commitments regarding climate change, energy security and energy prices. The geothermal companies will need to adapt.

Firstly, we have seen in Europe geothermal power plants built by utilities in situation of monopoly. For geothermal DH, the situation was different. When more power was needed in Europe due to the economic growth until end of the seventies, more installed capacity was required; for DH the competition with individual applications like boilers, was key. We can also consider the fact that when a DH was installed the obligation of the customers to connect was nearly obligatory.

Then, several changes happened in the business models of the companies due to their strategies to be integrated vertically or horizontally; or due to the regulations like the liberalisation of the energy markets.

The trends towards a low carbon economy requires the geothermal companies to adapt and to propose a new generation of geothermal 'products'.

2.3.2.1 Overview of the current business models

In situation of monopoly, utilities developed geothermal projects being partially integrated: engineering, drilling for some companies, turbines, connection to the grid, operation of the plant, and transmission & distribution of the electricity. The prices were often fixed by the State, so the business models had to adapt to this fact. As mentioned above, the need for more power was an opportunity to develop geothermal plants without this constraint.

In the DH sector, the issue was more the competition with fossil fuels.

The main change for the business models in the geothermal sector has been the European legislation developed in the nineties to liberalise the electricity and gas markets.

A second key change has been the climate and energy package 2020 and 2030 allowing an important development of renewable energy with support policies.

Today, geothermal companies seem less integrated than before. The newcomers are rather small companies and specialised. Integrated companies are rather rare and often only specialised in the underground or the surface systems. Recently, some mergers and acquisition lead to a consolidation of the companies in the sector.

The business models of the geothermal companies will continue to evolve but more due to the customer behaviour than to a centralised decision.

2.3.2.2 The District Heating sector

The main actors are the project developers, the DH operators and the services companies. In order to define the business model of a geothermal DH project, the heat customers are a key element. The presence of one large heat consumer helps the economy of a project greatly. Local DH utilities with a need for renewable and flexible heat supply, and building owners with a need of heat supply are two interesting customer segments.

Generally geothermal DH offers the heat consumer the following:

• Stable secure heat supply;

• Fixed, long term prices (for production and depreciation);

• Lower need for maintenance (compared to other conventional heat sources);

• Lower risks (when in operation);

• Ease and comfort for the end-user.

Geothermal DH technology is quite mature, in use for 50 years, and geothermal DH installations are competitive. However geothermal space and district heating systems are capital intensive, especially drilling the wells. Operating expenses, nevertheless, are rather low and much lower than in conventional systems. Generating costs and selling prices are usually around 60€/MWh thermal, within a range of 20 to 80€/MWh thermal. There are three frequently used financing models:

1. public investment undertaken by the local or regional authority (usually at municipal level);

2. private sector investment which in turn is granted the opportunity to sell the heat directly to the grid-connected subscribers over long duration (20 to 30 years contracts);

3. a 'mixed' solution, which entails the creation of companies dedicated to the development of the geothermal with capital investment shared by both public and private entities.

The first model (public scheme) has been developed mainly in Austria, Germany, and Denmark. The second (private DH utilities) is today used in France and the UK, among others. The third model, (a Public private Partnership) applies elsewhere and is gaining popularity in several European countries.

Two business models can be given as an example:

1. The case of a DH company decarbonising its heat supply in close cooperation with energy service companies (ESCOs). Here the main marketing strategy would be to combine sustainable heat supply (possibly with use of labels or certificates) and energy saving services so as to widen the scope of activity and reducing the impact of the inevitable reduction in energy consumption.

2. The second case would concern a geothermal DH project developer (public or private) aiming at proposing a new DH system supplied by geothermal. The objective would be to convince heat users of the value of renewable energy sources which are stable and competitive.

Finally, specific attention should be paid to multi-purposes uses. It is sometimes presented as an obvious solution for improving the economy of (notably) CH-P, but it seems less and less easy to develop them. Today few examples exist all over Europe.

2.3.2.3 The geothermal power sector

The geothermal electricity sector is composed of project developers, drillers, manufacturers, operators and utilities.

The business models aim at selling power at a competitive price, taking into account the high capital costs and the risk associated. Regarding economics of geothermal power 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.

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.

Project developers are diverse. Utilities are large companies but many developers in Europe are rather small and specialised in a phase of the project.

Utilities and oil&gas companies active in the geothermal sector are integrated vertically, having in general already the drilling rigs and crew.

For some years a new generation of developers in Europe proposes innovative business models. A Turbine manufacturer like Ormat is now proposing also to build power plants and sell electricity. The turbines manufacturer sector has been the most innovative. Mergers have led to horizontal integration (Turboden and MHI, Alstom and GE…). Small developers are specialised in project management and form consortia to develop the project. One of them, Fonroche, decided to acquire a rig in order to be more independent of the drilling market. Finally, we have seen in Turkey holdings diversifying their portfolio in being active in the power sector by developing geothermal projects. They have financial resources and often they create a geothermal company for the project development.

2.3.2.4 How to develop geothermal projects in Belgium

While power production from geothermal energy remains unfeasible now in Belgium due to unfavourable geological settings, efforts are concentrated on delivering heat. With a low to average geothermal gradient of 32°C per kilometre depth, exploiting heat for commercial use remains viable.

To foster successful geothermal projects in Belgium, a comprehensive approach is essential. Collaboration among diverse experts, understanding regulatory complexities, and integrating district heating are pivotal. The success of these ventures depends not only on subsurface technical feasibility (geosciences) but also on commercial viability, necessitating tailored infrastructures for efficient heat distribution to companies with long-term purchase agreements. Hence, a crucial balance between technical feasibility and commercial success is imperative.

Transparent communication about safety measures and benefits is vital to gain public acceptance, crucial for widespread adoption of geothermal energy exploitation.

Geothermal energy grows in significance due to evolving policies aimed at reducing reliance on fossil fuels and addressing disruptions in gas supplies. Its diverse applications, spanning from district heating to various industries, offer companies insulation from fluctuating gas prices. Technological advancements such as Ultra Deep Geothermal, Advanced Geothermal Systems, and Enhance Geothermal Systems play a crucial role in deploying Belgium's geothermal capabilities.

Targeting heat-dependent businesses, including large buildings, hospitals, aquaculture, agri-food, pulp and paper, biotechnologies, and chemical manufacturing, is crucial. Despite limitations in electricity production, leveraging geothermal heat aligns with companies' needs and environmental objectives, proving an advantageous energy solution for Belgian industries.

3. CHAPTER 3 - SYNTHESIS AND RECOMMENDATIONS

3.1 Synthesis about electricity policies

The European Union is in charge of laying the rules for the operation of the European electricity markets, with the objective of a unified European electricity market. Among the main measures carried forward by the EU is notably the unbundling of the networks (where producers of electricity and operators of the network have to be different), the opening of network to third party (so that monopolistic companies cannot prevent new actors to come and challenge their position). Besides, with the first renewable energy directive, the EU introduced the notion of priority dispatch and priority access for renewables. This allowed renewable energy producers to be sure to supply any electricity they produced to the grid – which alongside feed-in-tariffs was a key measure allowing the rapid development of renewable electricity capacity in Europe. Geothermal plants are among the beneficiaries of such incentives for new RES capacity, however this framework was changing with the consideration of several legislative proposals on the electricity market design by the European institutions.

The different legislative pieces of the Electricity Market Design were firstly agreed in 2019. It lays the foundation of an electricity market structured around renewable production and digitalization. It is also to guarantee the security and the continuity of the supply of electricity. To that end, the proposals go in the direction of greater exposure of renewable producers to the market (no priority dispatch/access for new plants except for demonstration projects and very small installations), and introducing capacity remuneration mechanisms to guarantee there is enough dispatchable capacity in a system with high intermittent capacity. However, the current policies fail to acknowledge the role that dispatchable and flexible renewable electricity sources such as geothermal can play in the future European electricity system.

High and volatile prices, such as those seen in 2022 provoked by Russia's energy war against the EU, have put an excessive burden on European electricity consumers. Many consumers saw their electricity bills increase due to the gas price surge, even though renewable energy sources are already covering more than a third of EU electricity demand. During the energy crisis, the EU reacted by introducing a wide range of measures to mitigate the impact of high and volatile wholesale energy prices on households and businesses. In addition, in March 2023, the Commission responded to the call of EU Leaders to come forward with a reform of the electricity market to secure European energy sovereignty and achieve climate neutrality with these proposals as part of the Green Deal Industrial Plan.

The new legislative proposal was recently agreed in December 2023. It aims to enhance the resilience of the EU’s electricity system; lessen exposure to energy price shocks from volatile fossil fuel utilisation; and ensure affordable electricity for families and industry.

A key feature of geothermal energy is its near permanent supply of renewable electricity coupled with its flexibility. This sets it apart from other renewable energy sources and fossil sources. Over 1 GWe of geothermal energy is currently installed in the EU. This number needs to quickly ramp up to meet the EU’s 2030 climate and energy targets. New EMD proposal helps geothermal by providing support measures that value the additional services it provides to Europe’s electricity system such as grid stability, system adequacy, flexibility and resilience.

One of the aspects of the EMD proposal is to increase the use of long-term contracts, such as Power Purchase Agreements (PPAs) and two-way “Contracts for Difference” (CfD) to provide households and businesses with more predictable and stable energy bills. From a geothermal energy perspective, PPAs and CfDs alone will be insufficient to cover upfront construction costs, which comprise the bulk of the total cost of a geothermal installation. Therefore, additional instruments will be required to ensure Europe benefits from the mass deployment of geothermal electricity.

Legislators must include provisions on tendering procedures for electricity from renewable energy sources as well as increasing the use of technology-specific and non-price criteria in auctions.

3.2 Current market conditions

The demand in Europe is stagnating. An issue for the power decarbonisation and the demand for new geothermal powerplants !

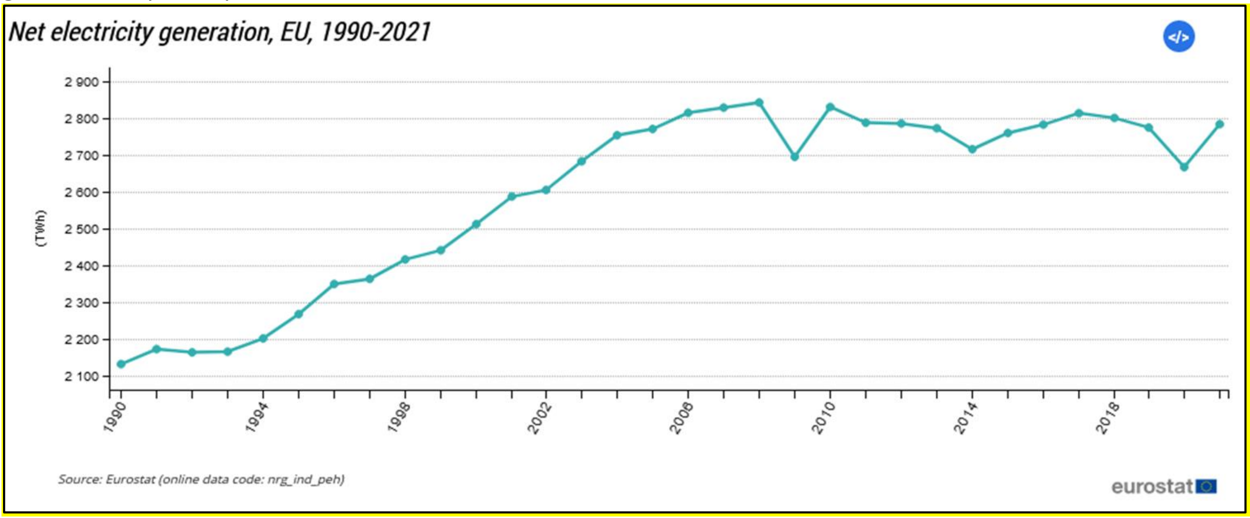


Figure 2: Net electricity generation in the EU, 1990-2021

In 2022, the wholesale average electricity price in Europe reached €230 per megawatt hour. This was 121% higher than in 2021. Italy had the highest wholesale electricity price on the daily market with (304 €/MWh on average).

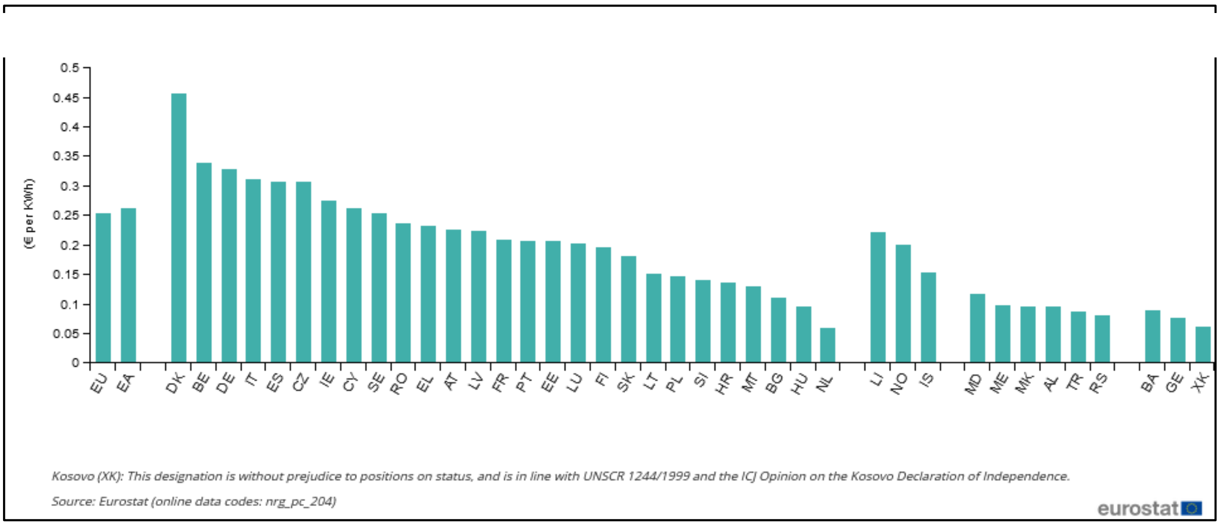


Figure 3 Electricity prices for household consumers (first half of 2022)

Source: Eurostat electricity price statistics

The share of renewable electricity increased from 38 % to 39 % between 2021 and 2022 whilst fossil fuels still represented 38 % of the EU's electricity production. In 2021, fossils produced 36% of the EU's electricity.

3.3 Recommendations

The recent Electricity Market Design (EMD) aims to enhance the resilience of the EU's electricity system; lessen exposure to energy price shocks from volatile fossil fuel utilisation; and ensure affordable electricity for consumers and industry. One of the aspects of the EMD proposal is to increase the use of long-term contracts, such as Power Purchase Agreements (PPAs) and two-way Contracts for Difference (CfD) to provide households and businesses with more predictable and stable energy bills.

From a geothermal energy perspective, PPAs and CfDs alone will be insufficient to cover upfront construction costs, which comprise the bulk of the total cost of a geothermal installation. Therefore, additional instruments will be required to ensure Europe benefits from the mass deployment of geothermal electricity.

The key challenge is to support new-build geothermal electricity plants which provide dispatchable (baseload) electricity.

New provisions on tendering procedures for RES electricity are required as well as increasing the use of technology-specific and non-price criteria in auctions. Geothermal electricity should be classified as infrastructure in relevant legislation, because of the system stability, flexibility and security that it provides.

The need of Base load for security of electricity supply should reward geothermal:

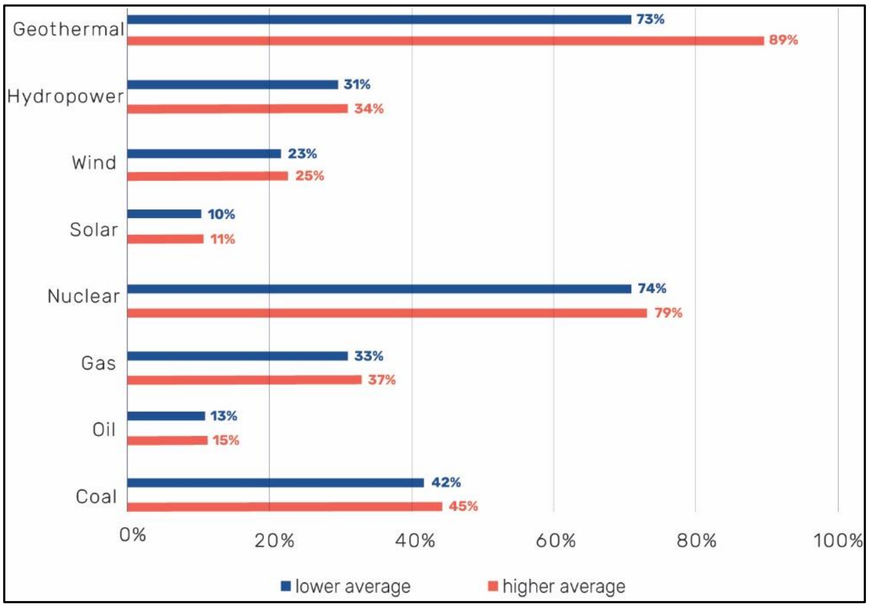


Figure 4 Average European capacity factor per electricity sources, 2022

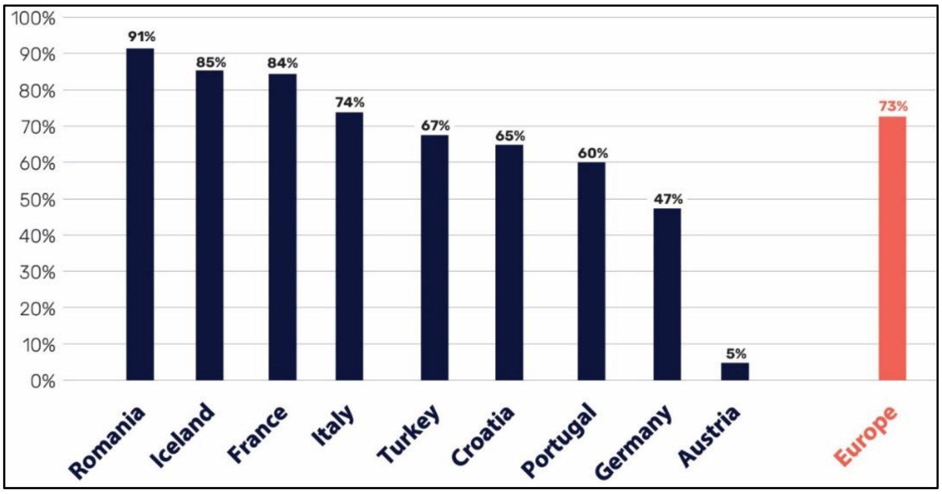


Figure 5 Average load factor of geothermal power plants, per country and overall

4. REFERENCES

Blog on GeoSmart project website: "GeoSmart explores Hybridization of Geothermal with Biomass", 2020.

European Technology and Innovation Platform on Geothermal (ETIP-G) (2023). "Strategic research and innovation agenda".

Factsheet GEOSMART: Geothermal Power Plants in the Electricity Market.

Factsheet GEOSMART: Energy Prices: the geothermal answer.

Webinar on GeoSmart project website: "Hybridization of Geothermal with Biomass and Concentrated Solar Thermal", 2023.