

Geothermal Energy Use, Country Update for Spain

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Keywords: Update, Spanish geothermal sector, geothermal resources, deep geothermal, shallow geothermal, geopower, geo-exchange, heat pumps, exchange systems, Spain, forecast, heating & cooling, geothermal education and training, GEOPLAT, GEOENERGÍA

ABSTRACT

The Spanish geothermal sector is progressing steadily, positioning itself as a reliable and competitive renewable energy source. The Recovery, Transformation and Resilience Plan (2021–2026) plays a pivotal role in this growth, providing funding, regulatory frameworks, and strategic support for geothermal deployment.

Key initiatives include the Deep Geothermal Energy Programme, which allocated € 111 million for feasibility studies of innovative projects on deep geothermal resources, with a strong focus on the Canary Islands. Additionally, financial incentives for geothermal heating and cooling systems have been implemented across residential and other sectors of the economy under Royal Decrees 477/2021 and 1124/2021, with increased budgets and extended timelines reflecting growing demand.

The establishment of GEOENERGÍA, the first Spanish geothermal association, marks a milestone in sector organization and advocacy. Additionally, the forthcoming development of two certificates of professional standards in geothermal system installation and maintenance is set to bolster professional skills and labor market integration, making Spain a reference point for geothermal training in Europe.

1. INTRODUCTION

Spain has a high potential for geothermal resources of different types (high, medium, and low temperature). If harnessed adequately through proper development initiatives, this geothermal potential could decrease the existing gap in the level of use of these resources with respect to other European nations. To enable this development, it is essential that the sector relies on an adequate support framework to undergo a sustained technological evolution.

Spain's geothermal potential could enable the inexhaustible use of this renewable energy source for the production of electricity as well as for residential use and services. This would also allow Spain to reduce its foreign energy dependency (above 75%), one of the biggest among EU countries and shown by many authors to be one of the real burdens to increase the competitiveness of the domestic economy. As well as to reduce the consumption of non-renewable energy sources and contribute to ultimately guarantee a constant supply of indigenous and reliable energy that is independent of external factors.

Table 1 provides a summary of the assessed geothermal resources in Spain.

Next, a description of the existing geothermal resources available in the Spanish subsurface is provided. This description includes the characteristics and potential of each resource, such as zones of interest, geological conditions, depth and temperature of the resource, fluid composition, etc.

The resources have been classified into the following groups to prepare such descriptions:

- Very Low-Temperature Resources ($T < 30\text{ }^{\circ}\text{C}$).
- Low-Temperature Resources ($30\text{ }^{\circ}\text{C} < T < 100\text{ }^{\circ}\text{C}$).
- Medium-Temperature Resources ($100\text{ }^{\circ}\text{C} < T < 150\text{ }^{\circ}\text{C}$).
- High-Temperature Resources ($T > 150\text{ }^{\circ}\text{C}$).
- Next-generation geothermal: Enhanced Geothermal Systems (EGS); Advanced Geothermal Systems (AGS).

Table 1. Geothermal resource potential in Spain. (Source: Evaluation of the geothermal energy potential. 2011-2020 PER technical study).

Type of use	Type of reservoir	Recoverable stored heat (10^5 GWh)	Power (MW)
Thermal	Low temperature (total resources)	15'682	5'710'320 (MW_{th})
	Low temperature (usable)	160	57'563 (MW_{th})
Electric	Medium temperature (total resources)	541	17'000 (MW_{el})
	Medium temperature (studied)	54	1695 (MW_{el})
	High temperature (studied)	1.8	227 (MW_{el})
	Enhanced geothermal systems (known areas)	60	745 (MW_{el})

2. GEOTHERMAL RESOURCES

2.1 Very low temperature ($<30\text{ }^{\circ}\text{C}$) – shallow - geothermal resources

Closed-loop geothermal systems: These resources are available nationwide. There are two main groups depending on the average thermal conductivity and the physical and mechanical characteristics of the ground.

Consolidated formations extending over 60% of the territory. Formed by sedimentary, igneous or metamorphic rocks ranging from Palaeozoic to Mesozoic age, specific weight greater than 2.0 tm/m^3 , the thermal conductivity in saturated conditions is over $2\text{ W/(m}\cdot\text{K)}$ and can be drilled without drilling mud or auxiliary casing except for a few starting meters. These formations occupy the entire periphery as well as the central mountain ranges. The conditions for implementing very low-temperature geothermal systems are optimal, especially when they go hand in hand with continental type climatic conditions.

Unconsolidated formations occupy broad areas across the two plateaus and the eastern third of the country. Geological conditions are less favorable, increasing the installations cost. However, these areas frequently have continental climatic conditions, with a great and well-equalized heating and cooling demand, improving the attractiveness of shallow geothermal systems in terms of LCE and cost.

Open-loop geothermal systems: There is a great use of groundwater, especially for urban and agricultural supply, in Spain. Usually, groundwater extraction involves deep aquifers, often with high pumping heights, increasing the energy cost over the shallow systems' redlines. In addition, complex regulations and hydrological stress in broad areas of the country do not facilitate their use in thermal applications. In practice, the greatest potential can be found in cascade applications, still scarcely developed, or more frequently in alluvial aquifers associated with the Spanish main rivers such as the Ebro, Guadalquivir, Guadiana, etc., standing many of the country's main cities (Zaragoza, Seville, etc.). These aquifers, very transmissive ($> 10^3\text{ m}^2/\text{d}$), supply open-loop geothermal systems of several hundreds of kW_{th} , just a few meters of drawdown.

In addition, a significant number of hotels are located in various coastal areas of Spain (islands and peninsulas), where the demand for hot water and cooling is being covered by geothermal open-loop systems using seawater.

According to the methodology provided in other sources (e.g., documents from the US Department of Energy such as "Geothermal (Ground-Source) Heat Pumps: Market Status, Barriers to Adoption, and Actions to Overcome Barriers. December 2008"), resources are not limited by ground conditions, but rather by demand configuration and our ability to harness the resources in a technically and economically viable way. In this sense Spain has many of the factors that favour geothermal heat pump based systems such as broad climatic areas with important seasonal temperature variations, large numbers of dwellings or buildings in rural or semi-urban areas with sufficient surrounding land and difficult access to gas or other sources and a deeply-rooted heating and cooling industry backed by broad experience.

2.2 Low temperature (30 - 100 °C) geothermal resources

The Spanish subsurface has been classified into two main groups for the purposes of analyzing this type of resource:

- 1) large sedimentary basins and peripheral mountain ranges
- 2) the Iberian Hercynian Massif

The first group includes the Duero, Tajo-Mancha-Júcar, Guadalquivir, Ebro and North-Cantabrian basins. The second group includes the Bética Ranges in addition to the Pyrenees, the Catalan Coastal Ranges

and the Iberian Hercynian Massif located in the west of the Iberian Peninsula. Within the areas that are included in the first group, there are numerous Mesozoic and Tertiary permeable formations that fill said basins, as described in studies prepared by IGME (Spanish Geological Survey) in the 1980s based on the information obtained from early deep hydrocarbon exploration wells. Geothermal energy in the form of recoverable stored heat (geothermal reserves) in such formations has been estimated at a total of $15'126 \cdot 10^5$ GWh. When focusing on areas near major urban centers with high thermal demand, the amount of recoverable and exploitable geothermal energy reaches to $150.3 \cdot 10^5$ GWh, representing approximately 1% of the total.

The areas included in the second group, which have been studied in detail by IGME from 1975, are characterized by significant regional fracturing coupled with a considerable vertical development of permeable formations that allow the proliferation of zones that host geothermal resources. Geothermal energy in the form of recoverable stored heat (geothermal reserves) in these zones has been estimated at $736 \cdot 10^5$ GWh. When focusing on areas near major urban centers with high thermal demand, the amount of recoverable and exploitable geothermal energy reaches to $9.6 \cdot 10^5$ GWh, representing approximately 1.3% of the total in these areas.

In summary, low-temperature geothermal energy estimates in the form of recoverable stored heat in Spain's subsurface amount to a total of $15'862 \cdot 10^5$ GWh, of which $159.9 \cdot 10^5$ GWh are located proximal to areas that have significant demand levels of this energy for direct heat applications.

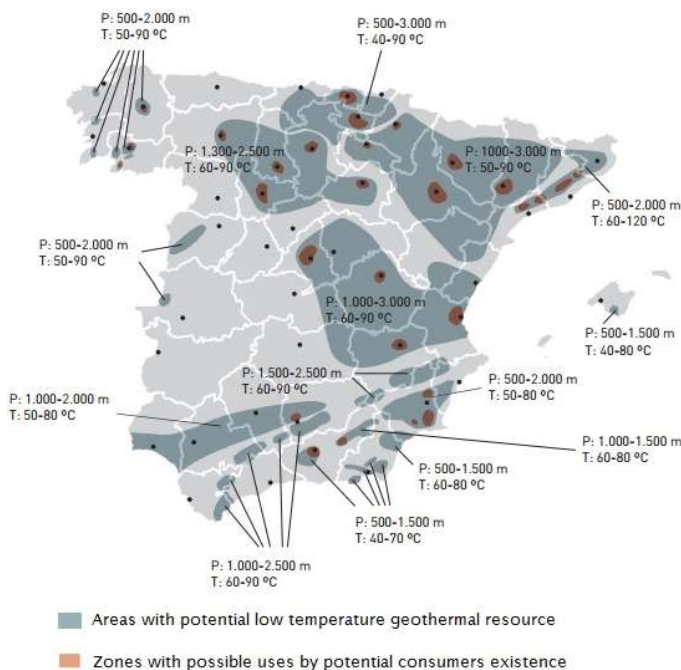


Figure 1. Map of low-temperature geothermal resources and zones with good potential for resource exploitation (Source: PER 2011-2020)

2.3 Medium temperature (100-150 °C) geothermal resources

The great depths that characterize some geologic basins in Spain that normally host permeable formations at depths greater than 3500 m allows for the existence of medium temperature geothermal resources suitable to be used in binary cycles for the combined production of heat and power. At these depths, the temperature of water contained in permeable formations exceeds 100 °C thanks to the geothermal gradient of the subsurface. In other zones, it is the considerable extent of regional fracturing that facilitates deep circulation of geothermal fluids. Thus, the areas located in the Cantabrian, Pre-Pyrenean, Tagus, Guadalquivir and Betic Range basins host deep permeable formations that contain fluids whose temperature exceeds 100 °C. In regions where crystalline rocks predominate, such as Cataluña and the Hercynian Massif (mainly in Galicia, northwestern Spain), regional fracturing favours the existence of these reservoirs thanks to the presence of fluids that circulate at depth. The studies carried out by IGME as well as earlier hydrocarbon exploration conducted by oil companies have allowed recognizing or estimating areas that can potentially host geothermal resources. These areas include La Selva and Vallès Neogene basins in Cataluña, the zone of Jaca- Serrablo in Aragón, the northern zone of the Madrid Basin, Lebrija in the Guadalquivir River Basin, a number of internal depressions in the Bética Ranges such as Lanjarón in Granada or Sierra Alhamilla in Almeria and some disperse areas in Galicia, Salamanca and Cáceres.

The gross potential of these resources in the form of recoverable stored heat in unexplored areas amounts to $541 \cdot 10^5$ GWh, which is equal to an installed capacity of $17'000$ MW_{el}. Geothermal resources in the form of recoverable stored heat in the abovementioned known or explored areas have been estimated at $54.23 \cdot 10^5$ GWh. Up to 1695 MW_{el} could be installed in binary cycle plants when considering performance, renewability and operating load factors.

2.4 High temperature (> 150 °C) geothermal resources

The conditions that enable the existence of high-temperature geothermal resources associated with active volcanism have been confirmed in Spain only in the Canary Islands. Previous investigations conducted by IGME and other entities have highlighted the possible existence of steam reservoirs or reservoirs involving a combination of steam and water in several areas of Tenerife (in the NW, E and S of the island). In other islands (Lanzarote and La Palma), several important thermal manifestations at the surface exist which, nonetheless, do not appear to indicate any possible storage of geothermal fluid.

In the three areas mentioned earlier on the island of Tenerife, the potential existence of geothermal storage zones has been estimated at depths between 2500 and 3500 m and temperatures in the range of 200-220 °C. Geothermal energy in the form of recoverable stored

heat in such zone has been estimated at $1.82 \cdot 10^5$ GWh. Up to 227 MW_{el} could be installed in conventional flash type plants when considering performance, renewability and operating load factors.

the more internal zone of the Bética Ranges in the vicinity of Sierra Nevada.

The geothermal energy that could be found in the form of recoverable stored heat in these areas has been estimated at $60 \cdot 10^5$ GWh, which would allow installing a total power capacity of 745 MW_{el} when considering the already mentioned performance, renewability, and usage load factors.

Currently, the technical and economic feasibility of developing Advanced Geothermal Systems (AGS) schemes in various regions of the Canary Islands and Catalonia is being evaluated.

3. SPANISH GEOTHERMAL SECTOR UPDATE

The Spanish geothermal sector is advancing step by step, establishing solid foundations to consolidate as a renewable, reliable, highly efficient, and competitive alternative in all its uses. This decade will be key to getting it off the ground in Spain.

3.1 Recovery, Transformation and Resilience Plan

The Spanish Recovery, Transformation and Resilience Plan (2021-2026)¹ details a comprehensive agenda of investments and reforms, specifying goals, objectives and indicators for follow-up and monitoring.

The Plan offers perspectives on the progress of geothermal energy in Spain. This plan facilitates the mobilization of public and private funds, promotes decarbonisation and energy efficiency, and supports the deployment of other renewable energies.

3.1.1 First call for feasibility studies of innovative projects on deep geothermal resources

On 28th April 2023, the Spanish Ministry for the Ecological Transition and the Demographic Challenge approved Order TED/467/2023² accepting the regulatory basis for granting support to medium to high-temperature geothermal resource project feasibility studies. Consequently, on 18th May 2023, the Institute for the Diversification and Saving of Energy (IDAE) published the first call resolution for the Deep Geothermal Energy Programme with funding of 120 million euros. The Deep geothermal energy Programme is part of the Recovery, Transformation and Resilience Plan for the deployment of the Next Generation EU funds in Spain. The proposed grants were economic incentives for the evaluation, analysis, and quantification of the geothermal resources in certain areas. It includes technical and economic evaluation, an assessment of the resources required for the execution of projects, the opportunities and risks, and an assessment of the prospects for project success.

The list of projects granted in the first call for feasibility studies of innovative projects on deep geothermal

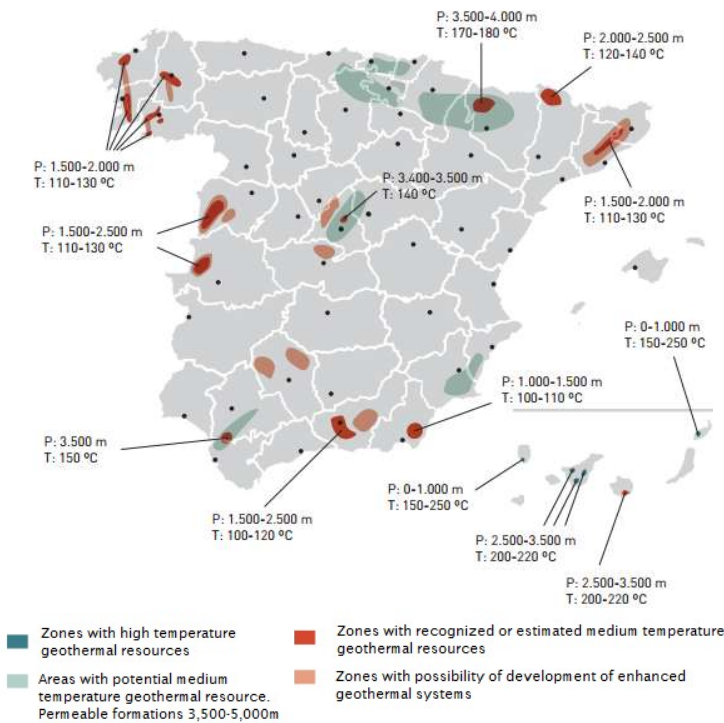


Figure 2. Map of medium and high-temperature geothermal resources and possible enhanced geothermal systems (Source: PER 2011-2020)

2.5 Next-generation geothermal: Enhanced Geothermal Systems (EGS) and Advanced Geothermal Systems (AGS)

The basic criteria used when selecting areas that have the potential for the development of EGS are:

- 1) the presence of a mass of crystalline rocks with low permeability at its matrix;
- 2) significant regional fracturing affecting this mass; and,
- 3) a certain degree of geothermal anomaly.

In light of these criteria, a detailed review of the peninsular geology has revealed a series of areas which, from a geological perspective, can allow the implementation of these enhanced geothermal systems. The areas considered are: the tectonic grabens of La Selva and Vallés in Cataluña, areas of deep fracturing in Galicia, the tectonic grabens in the SW of Salamanca (towns of Ciudad Rodrigo and Tormes), fractured areas west of Cáceres, the borders of the Tagus River depression, which are characterized by large-scale fractures that affect the Hercynian bedrock and lastly, areas in Andalucía where the granitic or Paleozoic bedrock is highly fractured, such as Sierra Morena or

¹ Plan Español de Recuperación, Transformación y Resiliencia: <https://planderecuperacion.gob.es/plan-espanol-de-recuperacion-transformacion-y-resiliencia>

² <https://www.boe.es/boe/dias/2023/05/09/pdfs/BOE-A-2023-11061.pdf>

resources (Deep Geothermal Energy Programme) was published on February 15, 2024³.

A total of eleven projects were granted funding between 1.2 and 15 million € per project, with a total sum of 111 million €. Ten out of the eleven projects are located in the Canary Islands, and as a whole, they received 90 % (106.2 million €) of the programme allocated budget, a territory with significant geothermal resource potential. Six of the projects - a total of 48 million € - will be developed in La Palma, three in Tenerife (43.2 million €), one in Gran Canaria (15 million €), and the last, which will receive a 5 million € grant, will be deployed in Madrid.

It should be noted that 55 % of the investment has been supported by the public sector, especially in the Canary Islands, which implies a real commitment by the local governments to the development of deep geothermal energy. The remaining 45 % has been provided by the private sector.

The feasibility studies cover the exploration, surveillance, and quantification of the geothermal resources at the selected sites, including the undertaking of deep boreholes with a 1000 metres minimum depth, the first of its kind in Spain. The results of the feasibility studies will be the basis for the future exploitation of these resources with the aim of deploying the first medium and high temperature geothermal plants for electricity generation or for direct thermal uses in the country. The feasibility studies are expected to be completed by 31 of January 2026 (extendable to 30 June 2026).

3.1.2 Geothermal heating and cooling systems in different sectors of the economy

Geothermal energy has benefited from several financial support programmes for renewable heating and cooling systems in different sectors of the economy within the framework of the Recovery, Transformation and Resilience Plan.

In 2021, two programmes aimed to promote renewable heating and cooling installations in the residential and tertiary sectors, in industry, and in district heating and cooling networks were launched. These programmes are coordinated by the Institute for Energy Diversification and Saving (IDAE), and each Autonomous Community must approve and publish their respective calls for aid:

- The Royal Decree 477/2021⁴ granted the Autonomous Communities and the Autonomous Cities of Ceuta and Melilla for the implementation of various incentive programmes linked to self-consumption⁵ of renewable energy and storage, as well as the implementation of renewable thermal systems in the residential sector. Geothermal energy is included under the *Implementation of thermal renewable energy installations in the residential sector* programme (Incentive Program 6).
- Royal Decree 1124/2021⁶ granted the Autonomous Communities and the Autonomous Cities of Ceuta and Melilla for the development of renewable energy installations for heating and cooling in different sectors of the economy. Eligible installation types include both open and closed-loop geothermal systems.

Due to the interest observed in both programs and their growing demand, according to the information provided by the autonomous communities, it was appropriate to extend their validity period until 31 July 2024, according to the Royal Decree 1178/2023⁷ (amending Royal Decree 1124/2021 and Royal Decree 477/2021). In addition, it was agreed to expand the budget for funding incentive programs due to two key factors:

1. The initial budget stated in RD 477/2021 was increased by € 220 million, plus an additional € 500 million through the addendum, as the original budget was exhausted.
2. Regional government budget increases: With the original allocation and the subsequent increase from RD 477/2021, regional governments that had a larger number of projects were granted budget increases upon request to IDAE:
 - Status of calls by Autonomous Community-Royal Decree 477/2021: Implementation of thermal renewable energy installations in the residential sector (Incentive Program 6)⁸.
 - Status of calls by Autonomous Community-Royal Decree 1124/2021: Renewable energy installations for heating and cooling in different sectors of the economy⁹.

The number of resolutions positively evaluated under these two incentive programs by 31 December 2024 (Tables 2 and 3) indicates the level of geothermal installations for thermal applications in the residential sector and various other sectors of the economy.

³ https://sede.idae.gob.es/sites/default/files/documentos/2024/GEOTERMIA/VIAGEO_Resol_definitiva_SEE_def.pdf

⁴ <https://www.boe.es/eli/es/rd/2021/06/29/477/dof/spa/pdf>

⁵ Self-consumption allows any person or company to produce renewable electricity for their own consumption by installing photovoltaic solar panels or other renewable generation systems in their home, premises or neighbourhood community. Any surplus is sold to the grid.

⁶ <https://www.boe.es/boe/dias/2021/12/22/pdfs/BOE-A-2021-21106.pdf>

⁷ <https://www.boe.es/buscar/doc.php?id=BOE-A-2023-26461>

⁸ <https://www.idae.es/ayudas-y-financiacion/para-energias-renovables-en-autoconsumo-almacenamiento-y-termicas-sector/estado-de-las-convocatorias-por-comunidad-autonoma-rd-4772021-climatizacion-renovable-residencial>

⁹ <https://www.idae.es/ayudas-y-financiacion/para-la-implantacion-de-instalaciones-de-energias-renovables-termicas-en/convocatorias-de-las-comunidades-autonomas>

Table 2. Closed-loop geothermal installations for heating and Cooling and/or DHW in the residential sector – RD 477/2021. Provisional data (Source: IDAE)

Autonomous Community	Nº facilites	Capacity (kW _{th})
Andalucía	23	923
Aragón	18	230
Cantabria	3	37,4
Principado de Asturias	N/A	N/A
Cataluña	146	2,110
Castilla-La Mancha	49	566
Castilla y León	72	886
Extremadura	1	11
Galicia	401	4,387
La Rioja	5	68
Canarias	N/A	N/A
Comunidad de Madrid	255	5,139
Comunidad Foral de Navarra	7	96
País Vasco	559	20'312
Comunitat Valenciana	2	23
TOTAL	1541	34'788

Table 3. Geothermal or hydrothermal installations for heating and cooling in different sectors of the economy¹⁰ – RD 1124/2021. Provisional data (Source: IDAE)

Autonomous Community	Nº facilites	Capacity (kW _{th})
Andalucía	5	3666
Aragón	12	3099
Cantabria	N/A	N/A
Principado de Asturias	2	93
Cataluña	25	2727
Castilla-La Mancha	18	7842
Castilla y León	20	1353
Extremadura	N/A	N/A
Galicia	33	3411
La Rioja	N/A	N/A
Canarias	2	1584
Comunidad de Madrid	9	1586
Comunidad Foral de Navarra	7	579
País Vasco	52	18'479
Comunitat Valenciana	4	1401
TOTAL	189	45'821

¹⁰ Agricultural and livestock sector, industrial sector, tertiary sector, public sector, residential sector, other sectors of the economy.

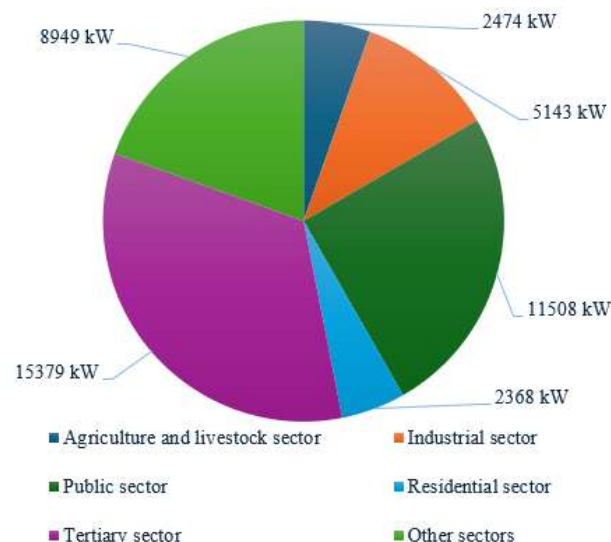


Figure 3. Capacity (kW) of geothermal or hydrothermal installations for heating and cooling by economic sectors – RD 1124/2021. Provisional data (Source: IDAE)

3.2 Geothermal heat pump sector

The official census on geothermal direct use and the ground source heat pump sector¹¹ of IDAE records a geothermal heating capacity of 222.16 MW_{th} in 2023 (Table 4). The published information refers to the park, power and thermal production, hours of operation, and SPF (Seasonal Performance Factor) of the heat pumps and includes heat pump statistics by climate zones, heat pump types, and sectors. These statistics are based on yearly installed Geothermal/Hydrothermal heat pump capacity in end-use sectors, collected from Autonomous Communities and administrative sources.

4. NEW INITIATIVES BOOSTING THE SPANISH GEOTHERMAL SECTOR

4.1 GEOENERGIA, the first Spanish Geothermal Association

On 9th May 2024, GEOENERGÍA¹², the first Spanish association to promote geothermal energy, was officially launched as a spin-off of GEOPLAT, the Spanish Technology and Innovation Platform on Geothermal. Born with the mission of being the voice of the geothermal sector in Spain, GEOENERGÍA will work for the development of the entire sector by advocating for a regulatory, political, and social framework that favors the sustainable implementation of geothermal energy in the territories, creating industry and providing environmental and socioeconomic value.

GEOENERGÍA arises from the need for a business association in Spain that brings together the private sector and defends its interests in the regulatory and market spheres. One of the priorities of GEOENERGÍA is to create regulatory and political proposals and strategies that promote the development of the

¹¹ <https://estadisticas-bombasdec calor.idae.es/>

¹² <https://www.geoenergia.es/>

geothermal sector, spread knowledge about geothermal, facilitate market intelligence, and enhance visibility of the agents that operate in this sector.

Table 4. Installed capacity of direct use and geothermal heat pump (GSHP) systems in Spain in 2023 (Source: IDAE)

Autonomous Community	Heating capacity (kW _{th})	Energy supplied by heat pumps (ERES) (toe)
Andalucía	10'700	1073
Aragón	43'293	4765
Canarias	12'700	1089
Cantabria	1103	167
Castilla y León	9943	1254
Castilla-La Mancha	4204	431
Cataluña	14'136	1595
Comunidad de Madrid	48'299	5837
Comunidad Foral de Navarra	2749	664
Comunitat Valenciana	5763	483
Extremadura	506	47
Galicia	14'232	1322
Islas Baleares	7876	422
La Rioja	1573	189
País Vasco	32'113	3926
Principado de Asturias	12'820	1744
Región de Murcia	150	9
TOTAL	222'160	25'017

The organization will establish synergies and alliances within the sector, thus stimulating advancements and making information available for strategic decision-making.

The launch of GEONERGÍA was done at the Institute for Energy Diversification and Saving (IDAE), an institution attached to the Ministry for the Ecological Transition and Demographic Challenge.

GEOPLAT and GEOENERGÍA will be integrated into the Red Geotérmica Estatal¹³ (State Geothermal Network), which will connect all public-private agents in the geothermal sector. The Network will increase the sector's visibility through Geo MApp¹⁴, the largest visual database of entities in the field of geothermal energy in Spain, which has public access.

4.2 Collaborative network of European geological survey organisations

Meanwhile, a reevaluation of Spain's resource potential and the rest of the Iberian Peninsula is being conducted

within the PanEU Atlas of the Sustainable Geoenery Capacities project, coordinated by IGME, ICGC (Cartographic and Geological Institute of Catalonia) and LNEG (Geological survey of Portugal) as part of the GSEU project (2022-2027), funded by Horizon Europe, based on a modified version of a play-based geothermal exploration approach (Moeck, 2020).

The specific objectives of the GSEU project¹⁵ are to develop pan-European harmonised data and information services in Europe with a focus on:

- Critical raw materials
- Geothermal energy resources and subsurface storage capacities for sustainable energy carriers and CO₂ sequestration
- Groundwater dynamics and quality, geological and climate change information for coastal vulnerability assessment and geological baseline information.

4.3 Mineral Raw Materials Action Plan

The Ministry for the Ecological Transition and the Demographic Challenge (MITECO) launched the public consultation process for the 2025-2029 Mineral Raw Materials Action Plan, a strategy aligned with the European Union to transform the mining industry with a focus on recycling, sustainability, and supply security.

Among the key measures is the creation of the National Mining Exploration Programme, which will analyse more than 1,000 tailings ponds and spoil heaps in search of strategic resources, as well as the updating of regulations to expedite the restoration of closed mining operations. The programme, which will emphasise public-private collaboration, will have its own financial resources, including two aid schemes: one for identifying unrecognised resources and another for waste facility management. This Action Plan aims to establish Spain as a benchmark for sustainable mining, ensuring key resources for the future of the economy and industry.

The Plan also includes several actions related to medium—and high-temperature geothermal energy, including identifying areas of interest for medium—and high-temperature geothermal resource fields.

5. GEOTHERMAL EDUCATION AND TRAINING IN SPAIN

In 2024, the Directorate General of Vocational Training of the Spanish Ministry of Education, Vocational Training and Sports will begin working on the development of two professional certificates based on the first professional training qualifications on managing the installation and maintenance of geothermal heat exchange systems that were published in the State Agency for the Official State Gazette (BOE) in 2021¹⁶:

¹³ <https://redgeotermica.es/>

¹⁴ <https://redgeotermica.es/mapp>

¹⁵ GSEU project: <https://www.geologicalservice.eu/>

¹⁶ https://www.boe.es/diario_boe/txt.php?id=BOE-A-2021-8975

- ‘Installations, commissioning and maintenance of closed-loop geothermal exchange facilities’ (level 2)
- ‘Organization and projects of closed-loop geothermal exchange facilities’ (level 3)

GEOPLAT worked jointly with the National Institute of Qualifications of the Spanish Ministry of Education (INCUAL) to develop the material for these professional qualifications. GEOPLAT assessed the technical work and developed the necessary professional modules to adapt the qualifications to professional certificates.

The National Catalogue of Professional Qualifications is the basis upon which is developed the training offer aimed to obtain the vocational education and training (VET) Diplomas, Certificates of Professional Standards and the accumulative modular training offer linked to a unit of competence as well as other training offers adapted to people with special needs¹⁷.

Certificate of Professional Standards is the official accreditation instrument for the professional qualifications of the National Catalogue of Professional Qualifications in the Labour Administration. The certificate accredits the capacity for the development of a working activity with significance in employment and ensures the training in the framework of VET for employment. One Certificate of Professional Standards shapes a professional profile as a set of professional competences identified in the productive system, recognized and valued in the labour world.

The publication of these certificates is expected throughout 2025, strengthening professional development and fostering employability in a growing sector, offering opportunities for new specialized profiles. They will also recognize and enhance the professional experience of workers that can be demonstrated in accordance with these standards, facilitating employability and mobility in the labor market, as well as the professional development of workers in the field of renewable heating and cooling. These professional certificates are among the first published in both Spain and Europe on geothermal heating and cooling systems for buildings. This represents an unprecedented milestone for both the Spanish and European geothermal sectors, serving as a benchmark for other Member States.

6. CONCLUSIONS

The geothermal sector in Spain is experiencing progressive and structured growth, supported by robust public policies, targeted financial mechanisms, and a clear long-term vision. This development positions geothermal energy as a key component of the national renewable energy mix, with significant potential for both electricity generation and direct-use applications.

A central driver of this momentum has been the Spanish Recovery, Transformation and Resilience Plan, which has facilitated the mobilization of substantial public and private investment. Through initiatives like the Deep Geothermal Energy Programme, and funding schemes for renewable heating and cooling, Spain has created a favourable environment for the exploration, evaluation, and eventual exploitation of geothermal resources.

The Deep Geothermal Energy Programme will boost an undeveloped part of the Spanish Geothermal sector: plants for power generation. The Spanish geothermal energy sector is committed to this call for proposals, which will open new avenues for action and allow new public and private players to enter the geothermal sector.

The Canary Islands have emerged as a strategic hotspot within this framework. Due to their exceptional geothermal potential, they receive the majority of the funding for deep geothermal feasibility studies. This concentration of activity may position the archipelago as a future leader in high-temperature geothermal deployment in Spain.

In parallel, the increasing number of geothermal installations for thermal applications in residential, commercial, and industrial sectors reflects the growing acceptance and integration of this technology across the country. Autonomous Communities such as the Basque Country, Madrid, and Galicia are particularly active, highlighting regional leadership and the decentralization of geothermal development.

The creation of GEOENERGÍA, the first Spanish geothermal business association, marks a significant step toward consolidating the sector's private interests and ensuring effective advocacy. Its establishment will contribute to the creation of a supportive regulatory and political framework, while enhancing visibility and coordination among stakeholders.

Furthermore, Spain is developing specialized professional training to meet the technical demands of the growing heating and cooling geothermal industry. The forthcoming development of official professional certificates in geothermal system installation and project management reflects a broader commitment to workforce development. These certifications are expected to improve professional recognition and employability, while setting a European benchmark in geothermal education.

Overall, with strong institutional support, increasing market interest, and a foundation in training and regulation, Spain is well-positioned to become a leading country in geothermal energy development in the coming decade.

¹⁷ National System for Qualifications and Vocational Education and Training. National Institute of Qualifications, INCUAL.

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Acknowledgements

This work wouldn't have been possible without the collaboration of Spanish geothermal stakeholders and the work of the secretariat of the Spanish Technology and Innovation Platform on Geothermal - GEOPLAT.

Tables A-G

Table A: Present and planned geothermal power plants, total numbers

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total electric power generation	
	Capacity (MW _e)	Production (GWh _e /yr)	Capacity (MW _e)	Production (GWh _e /yr)	Capacity (%)	Production (%)
In operation end of 2024	0	0	132'343 ¹⁸	262'247	0	0
Under construction end of 2024	0	0				
Total projected by 2028						
Total expected by 2032						
In case information on geothermal licenses is available in your country, please specify here the number of licenses in force in 2024 (indicate exploration/exploitation if applicable):					Under development:	
					Under investigation:	

Table B: Existing geothermal power plants, individual sites

No geothermal power plants exist in Spain at present.

¹⁸ Source: Red Eléctrica <https://www.sistemaelectrico-ree.es/informe-del-sistema-electrico/potencia-instalada>

Table C: Present and planned deep geothermal district heating (DH) plants and other uses for heating and cooling, total numbers

No geothermal district heating plants or other deep geothermal uses for heating and cooling exist in Spain at present and neither are planned currently.

Table D1: Existing geothermal district heating (DH) plants, individual sites

Spain lacks a centralized or official registry of geothermal district heating installations. Therefore, the precise number, capacity, and geographic distribution of such plants cannot be accurately established.

Table D2: Existing geothermal large systems for heating and cooling uses other than DH, individual sites

Spain does not have an official inventory of large-scale geothermal systems for these purposes, making it impossible to provide a comprehensive and verified account of existing facilities.

Table E1: Shallow geothermal energy, geothermal pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in the year 2024 *		
	Number	Capacity (MW _{th})	Production (GWh _{th} /yr)	Number	Capacity (MW _{th})	Share in new constr. (%)
In operation end of 2024 *	296*	222.16*	388*			
Of which networks **						
Projected total by 2028						

* If 2023 numbers need to be used, please identify such numbers using an asterisk

** Distribution networks from shallow geothermal sources supplying low-temperature water to heat pumps in individual buildings (“cold” DH, Geothermal DH 5.0 etc.)

Table F: Investment and Employment in geothermal energy

	in 2024		Expected in 2028	
	Expenditures ** (million €)	Personnel *** (number)	Expenditures ** (million €)	Personnel *** (number)
Geothermal electric power	N/A	N/A	N/A	N/A
Geothermal direct uses	N/A	N/A	N/A	N/A
Shallow geothermal	N/A	N/A	N/A	N/A
total				

* Expenditures in installation, operation and maintenance, decommissioning

** Personnel, only direct jobs: Direct jobs – associated with core activities of the geothermal industry – include “jobs created in the manufacturing, delivery, construction, installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration”. For instance, in the geothermal sector, employment created to manufacture or operate turbines is measured as direct jobs.

Table G: Incentives, Information, Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D	YES	YES	YES
Financial Incentives – Investment	NO	NO	DIS LIL
Financial Incentives – Operation/Production	NO	NO	DIS LIL
Information activities – promotion for the public	YES	YES	YES
Information activities – geological information	YES	YES	YES
Education/Training – Academic	YES	YES	YES
Education/Training – Vocational	NO	NO	YES
Key for financial incentives:			
DIS	Direct investment support	FIT	Feed-in tariff
LIL	Low-interest loans	FIP	Feed-in premium
RC	Risk coverage	REQ	Renewable Energy Quota
TC	Tax credits	O	Other (please explain)
		-A	Add to FIT or FIP on case the amount is determined by auctioning