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Country Update for the Spanish Geothermal Sector

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ABSTRACT

The Spanish geothermal sector is showing an unequal behavior during the last years, while shallow geothermal continues experiencing a steady growth, as it becomes more popular and increasingly applied in the building refurbishment subsector, geothermal for power generation is completely blocked due to the situation of the Spanish electricity sector, - with a moratorium on new renewable energy developments still in force - and the ongoing discussions around a new regulatory framework.

Spain has been one of the last European countries where is geothermal energy started; this explains why our country is behind most EU nations in practically all areas of the sector. Nevertheless, there are expectations for a future development on shallow geothermal for HVAC as well as for power generation, given the existing potential and resources.

At present, there is no geothermal power generation in Spain. However, several business initiatives have shown a growing interest in developing this type of project in the short and medium term. In addition, the Spanish geological setting is very favourable for the development of EGS type projects but these developments are subject to an improvement of the regulatory and market conditions.

With regard to low-temperature geothermal energy, Spain's current installed capacity (built during the 80's) is associated with direct heat applications, mainly in SPA and greenhouse appliance. Current estimates foresee that this type of applications will only experience little additional increases. In addition, it is estimated that from 2015 onwards, several heating and cooling network projects (geothermal district cooling and heating) may be launched.

Furthermore, shallow or very low temperature geothermal energy used for cooling and heating is already a reality in our country. Although no definite data are available on the installed capacity of geothermal energy in Spain, estimates of 150 MWt have been reported, allowing the parallel development of a new industry in this sector.

1. INTRODUCTION

Spain has different types of high potential geothermal resources, which, if harnessed adequately through proper development initiatives, can decrease the gap in the level of use of these resources with respect to other European nations. To enable this development, it is essential and indispensable that the sector undergoes sustained technological evolution.

Spain's geothermal potential can enable the inexhaustible use of this renewable energy source for the production of electricity in the industrial and agricultural sectors as well as for residential use and services. This would also allow us to reduce our foreign energy dependency (the real burden of our domestic economy), reduce the consumption of non-renewable energy sources and contribute to ultimately guarantee a constant supply of energy that is independent of external factors.

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

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	7,710.320 (MWt)
	Low temperature (usable)	160	57,563 (MWt)
Electric	Medium temperature (total resources)	541	17,000 (MWe)
	Medium temperature (studied)	54	1,695 (MWe)
	High temperature (studied)	1.8	227 (MWe)
	Enhanced geothermal systems (known areas)	60	745 (MWe)

2. UPDATE OF CURRENT ACTIVITIES IN THE SPANISH GEOTHERMAL SECTOR

A description of the existing geothermal resources available in the Spanish subsurface is provided next. 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 in order to prepare such descriptions:

- Very Low Temperature Resources (T < 30ºC).
- Low Temperature Resources (30ºC < T < 100ºC).
- Medium Temperature Resources (100ºC < T < 150ºC).
- High Temperature Resources (T > 150ºC).
- Enhanced Geothermal Systems (EGS).

2.1 Very low temperature (<30ºC) – shallow - geothermal resources

Closed-loop geothermal systems. These resources are available nationwide for geothermal heat pumps. The current installed capacity is estimated at about 60 MWt. There are two main groups depending on the average thermal conductivity and the physical and mechanical characteristics of the ground.

Consolidated formations extend over 60% of the territory area. Formed by sedimentary, igneous or metamorphic rocks ranging from Paleozoic to Mesozoic age, specific gravity greater than 2.0 t/m^3, thermal conductivity in saturated conditions over 2 W/mK and can be drilled without drilling mud or auxiliary casing except 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 financial ratios of viability reports of these systems.

Open-loop geothermal systems. There is a great use of groundwater, especially for urban and agricultural supply, in Spain. Many times 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 usually in alluvial aquifers of Spanish main rivers such as the Ebro, Guadalquivir, Guadiana, etc., are located many of the country's main cities (Zaragoza, Seville, etc.). These aquifers, very transmissive (> 103 m^2/day), supplies open-loop geothermal systems of several hundreds of kW, pumping just a few meters. The actual installed power capacity of these open-loop systems is assessed on 90 MWt.

Following 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"), resource estimates in this case would not be limited by soil conditions, but rather by demand configuration and our ability to harness the resources in a technically and economically viable way. In this sense, there are great areas with potential demand. Spain has many of the factors that favor 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. Also worth noting are the dramatic changes that have taken place in the regulatory sphere (articulated by a diverse range of technical codes and regulations in the case of Spain) which have resulted in the implementation, since 2009, of the European Renewable Energy Directive relative to the promotion of the use of energy from renewable sources (hereinafter Directive 2009/28/CE) in buildings or other previous codes. In the last years, the slowdown of the building sector has resulted in slower uptake of new projects and an increased attention to the possibilities of shallow geothermal in the refurbishment of existing buildings.

2.2 Low temperature (30 – 100ºC) geothermal resources

The Spanish subsurface has been classified into two main groups, for purposes of analyzing this type of resource: 1) large sedimentary basins and peripheral mountain ranges and 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. As described in studies prepared by IGME (Spanish Geological Survey) in the 80's based on the information obtained from deep hydrocarbon exploration wells there are numerous Mesozoic and Tertiary permeable formations that fill the large sedimentary basins included in the first group. Geothermal energy in the form of recoverable stored heat (geothermal reserves) in such formations has been estimated at a total of 15,126 x 10^5 GWh. When applying the calculation to zones of influence in key urban centers that have significant thermal demand, this figure goes down to 150.3 x 10^5 GW, which is approximately 1% of the total.

The areas included in the second group are characterized by significant regional fracturing coupled with a considerable development of vertical permeability that allows the circulation of geothermal fluids. Geothermal energy in the form of recoverable stored heat (geothermal reserves) in these zones has been estimated at 736 x 10^5 GWh. When applying the calculation to zones of influence in key urban centers that have significant thermal demand, this figure get down to 9.6 x 10^5 GW, which is 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 amounts to a total of 15,862 x 10^5 GWh, of which 159.9 x 10^5 GWh are located proximal to areas that have a significant direct heat energy demand (Figure 1).

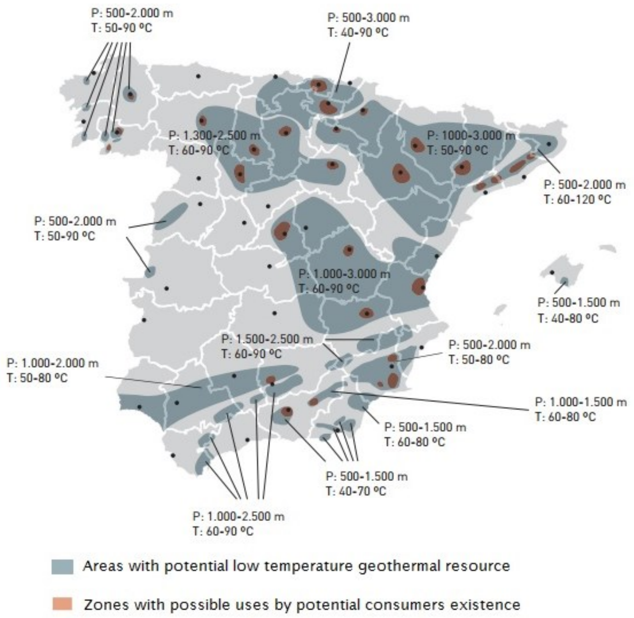

Figure 1. Map of low temperature geothermal resources and zones with good potential for resource exploitation (Source: PER 2011-2020)

2.3 Medium temperature (100-150ºC) geothermal resources

Some geologic basins in Spain host permeable formations at depths greater than 3,500 m, and those conditions allow the presence 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 the permeable formations exceeds 100ºC. 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 containing fluids with temperatures greater than 100ºC. In granitic regions, such as Cataluña and the Hercynian Massif (mainly in Galicia, northwestern Spain), regional fracturing favors the existence of geothermal reservoirs thanks to the deep circulation of fluids. The studies carried out by IGME as well as hydrocarbon exploration conducted by oil companies are showing the most geothermal resource potential areas. These areas include La Selva and Vallés depressions 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 (Figure 2).

The gross potential of these resources, in the form of recoverable stored heat in unexplored areas, amounts to 541 x 10^5 GWh, which is equivalent to an installed capacity of 17,000 MWe. Geothermal resources in the form of recoverable stored heat in the above mentioned known or explored areas have been estimated at 54.23 x 10^5 GWh. Up to 1,695 MWe could be installed in binary cycle plants taking into account performance, renewability and operating load factors.

2.4 High temperature (> 150ºC) geothermal resources

Active volcanism provides the necessary conditions that enable the existence of high temperature geothermal resources in 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 like Lanzarote and La Palma, geothermal surface manifestations don't appear to indicate the presence of geothermal reservoirs at depth (Figure 2).

In the island of Tenerife, the potential existence of geothermal reservoirs has been estimated at depths between 2,500 and 3,500 m and temperatures in the range of 200-220ºC. Geothermal energy in the form of recoverable stored heat in such zone has been estimated at 1.82 x 10^5 GWh. Up to 227 MWe of conventional flash type could be installed in taking into account geothermal resource performance, sustainability and operating load factors.

2.5 Enhanced Geothermal Systems (EGS)

The basic criteria used when selecting areas that have the potential for the development of EGS are: 1) the presence of a low permeable granitic or metamorphic formation; 2) significant regional fracturing affecting the rocks; and, 3) a certain degree of geothermal anomaly. In light of these criteria, a detailed review of the peninsular geology has revealed several areas which 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 basement and finally, areas in Andalucía where the Paleozoic basement is highly fractured, such as Sierra Morena or the the Bética Ranges internal zone in the vicinity of Sierra Nevada (Figure 2). The geothermal energy that could be found in the form of recoverable stored heat in these areas has been estimated at 60 x 10^5 GWh, which would allow installing a total power capacity of 745 MWe when taking into account the already mentioned performance, sustainability and usage load factors.

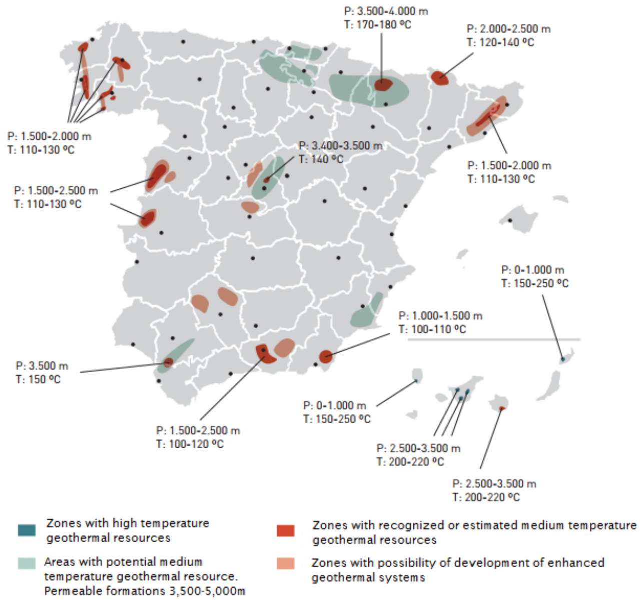

Figure 2. Map of medium and high temperature geothermal resources and possible enhanced geothermal systems (Source: PER 2011-2020)

3. INSTITUTIONAL ACTIVITIES

Originated in Europe, Directive 2009/28/CE brought a clear proposal to the table for the promotion of the use of energy from renewable sources and for implementing efficiency measures aimed at improving the end consumption of energy. A key milestone was established in this respect: the year 2020, in addition to a set of mandatory targets to be achieved in said year that require high levels of competitiveness and excellence during this period.

Although still at incipient stages of development but with an enormous potential to contribute to these targets, geothermal energy must not lag behind and must face the challenge of becoming an additional, real and accessible option in the energy market up to the year 2020.

In Spain, the 2011-2020 Renewable Energy Plan (PER) constitutes the strategic roadmap that was prepared by the Government with the purpose of providing the necessary instruments that would allow integrating the particularities of our situation with the energy potential of our country for developing a sustainable national energy model. In this sense, the 2011-2020 PER represents a milestone in the Spanish geothermal sector since, after decades of absence, geothermal energy, our energy, once again becomes part of national energy planning and its potential contribution thereto is taken into account.

A gross potential of 3,000 MWe has been estimated according to the 2011-2020 PER, which can be harnessed through conventional or enhanced geothermal systems for the generation of electricity. It has been stated that the challenge that must be overcome to develop this sector would be to find the manner in which geothermal resources can be tapped in a technically and economically viable way. In this respect, the 2011-2020 PER states that new drilling methods must be developed. Furthermore, the 2020 50 MWe target still remains, and the 2011-2020 PER indicates that plants will begin to be developed starting in 2017, linking their pace of development to potential drilling risks and the development of new enhanced geothermal systems technology. In addition, it is stated that Spain has an installed thermal capacity greater than 100 MWt and that the geothermal energy potential for thermal uses can exceed 50,000 MWt. Some of the challenges that must be overcome to promote further the development of the sector include the reduction of thermal energy generation costs and the increase in heat pump efficiency.

Moreover, the 2011-2020 PER specifies the targets that this technology must achieve by 2020, both in terms of electricity and heat:

- Electricity production targets. The 2020 target in the use of geothermal energy for the production of electricity is set to 50 MWe.

	2010		2015		2020	
	MW	GWh	MW	GWh	MW	GWh
Hydro (w/o pumping)	13,226	42,215	13,548	32,538	13,681	33,140
<1 MW (w/o pumping)	242	802	253	772	268	843
1-10 MW (w/o pumping)	1,680	5,432	1,764	4,982	1,917	5,749
>10 MW (w/o pumping)	11,304	35,981	11,531	26,784	11,676	26,548
With pumping	5,347	3,106	6,312	6,592	8,811	8,457
Geothermal	0	0	0	0	50	300

- Heat production targets.

ktoe	2010	2011	2015	2020
Geothermal energy (excluding low temperature geothermal heat in heat pumps applications)	3.8	3.8	5.2	9.5
Thermal solar energy	183	190	308	644
Biomass	3,729	3,779	4,060	4,653
Solid (includes waste)	3,695	3,740	3,997	4,553
Biogas	34	39	63	100
Renewable energy from heat pumps	17.4	19.7	30.8	50.8
Of which, aerothermal represents	5.4	5.7	7.4	10.3
Of which, geothermal represents	12.0	14.0	23.4	40.5
Total	3,933	3,992	4,404	5,357

It is estimated that the production of thermal energy from geothermal sources will occur through the use of heat pumps, to which a partial target of 40.5 ktoe has been assigned (representing about 471 GWh) and direct heat uses. In the latter case, a partial target of 9.5 ktoe has been assigned (about 110.5 GWh).

Based on analyses of the sector (which were eventually used as a source of information for the preparation of the 2011-2020 PER), the latter is expected to grow based on two scenarios (Figure 3). Both suggest that the penetration ratios of shallow geothermal energy through the use of heat pumps will converge toward the 2010 levels of two of our neighboring countries that were chosen as a reference (France, with similar climate and market configuration) and Austria, with maximum levels of penetration of GSHP in terms of installed capacity per capita. Convergence to such rates is shown in the following chart and is perhaps the most reliable market potential indicator at present. It is worth noting that the values that were used for its preparation are quite less ambitious than those reflected in said market potential charts.

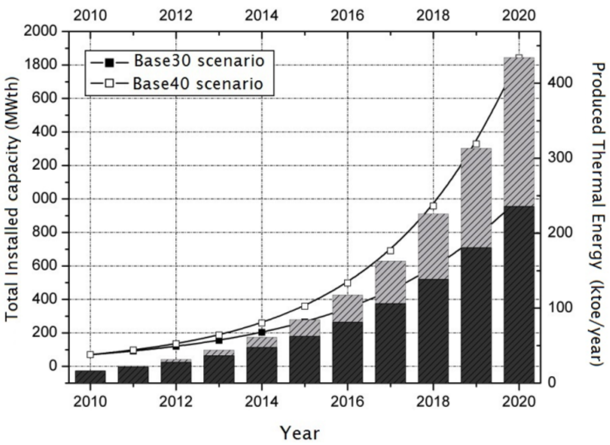

Figure 3: trend chart showing the potential growth of GSHP in the Spanish market based on two scenarios.

Although the targets that were established in the 2011-2020 PER are quite far from the actual generation potential displayed by both high enthalpy geothermal systems for electricity production and low enthalpy geothermal systems for heat production, the sector values strongly that one of the youngest renewable energy sources in Spain has been taken into consideration at last, and that a series of specific measures have finally been proposed to promote their development in the coming years.

4. POLICY UPDATES

The framework regulating the Spanish geothermal sector is of paramount importance in the sense that the presence or lack of concrete policies and initiatives within such a regulatory framework is considered to be a determining factor in the development of the sector.

On the one hand, the adoption in 2013 of the following regulations is another obstacle in the development of geothermal energy for power generation in Spain:

Royal Decree-Law 2/2013, of the 1 of February of 2013, on urgent measures in the electricity system and in the financial industry. The method of CPI-linked updating of remuneration applicable to the sale of electricity by installations falling under the special regime changes. The reference premium for electricity generation installations falling under the special regime which have chosen the option of selling the electricity generated in the market is eliminated. The possibility of changing the remuneration option for electricity generation installations falling under the special regime which choose the option of selling the electricity generated in the market is eliminated.

Energy Sector Reform. The Energy Sector Reform package is made up of a series of different pieces of legislation: a royal decree-law ("RDL 9/2013"), a series of royal decrees and several ministerial orders. Between them must be highlighted the draft of the

Royal Decree which regulates the production of electricity from renewables, CHP and waste. In this draft geothermal for electricity is still considered a novel energy. And it does not introduce any measure to improve or boost the deployment of this energy in Spain. It follows that there is not a real political will or even interest on geothermal for electricity production in Spain. Nevertheless, this fault of interest is paradoxical (to say the least). Electricity generated by geothermal energy has an unquestionably competitive cost, it is completely dispatchable, and has the capacity to act as base load. All of them valuable features that should be known and adequately valued by the Spanish decision-makers.

On the other hand, the legislative package, approved by the Spanish Council of Ministers on the 5th of April 2013, to stimulate the deployment of renewable energies, mainly for heating & cooling purposes in the residential sector:

- **Royal Decree 233/2013** of 5 April that regulates the State Plan to promote rental housing, rehabilitation, recovery and urban renewal for the period of 2013-2016. It includes eight grant programs for the energetic rehabilitation of existing buildings of the residential sector (dwelling and hotel use). Substitution of conventional energy by renewable energies (biomass, geothermal) in thermal installations is within the scope of the grants:
    - Subsidized loans program
    - Housing rental aid program
    - Rented public housing stock program
    - Building refurbishment program
    - Urban regeneration and renewal program
    - Support program to introduce the building assessment report
    - Sustainable and competitive cities program
    - Support program to introduce and administer the National Plan
- **Royal Decree 235/2013 of the 5 April of 2013**. Its approving the basic procedure for the certification of energy efficiency of buildings limits itself to transpose the first European directive on energy efficiency of buildings 2002 (2002/91/EC) as regards to existing buildings, but with ten years of delay. In its second additional provision the Royal Decree incompletely transposes Art. 9 of the new Directive on energy efficiency of buildings (2010/31/EU) whose deadline for transposition ended in January 2013 concerning the requirement that buildings should be of almost zero energy consumption by 2020, but in Article 1 of the basic procedure of certification it deletes the concept of near/net zero energy buildings contained in the draft. The concept which the directive is defining in that sense is very clear, being buildings that are supplied by renewable energies and/or self-consumption. By not defining this concept in the Royal Decree, the sought normative figure actually remains nonexistent.
- **Royal Decree 238/2013 of the 13 of April of 2013**. It's modifying some technical instructions of the Regulation for Thermal Installations of Buildings (RITE) with the aim of transposing the provisions for thermal installations in buildings of the new Directive on energy efficiency of buildings (2010/31/EU) into Spanish law, like for example including a greater number of heating & cooling facilities in the scope of application of the RITE.
- **Law 8/2013 of the 26 of June 2013**. Its main aims are to establish an appropriate regulatory framework to carry out activities/actions of urban rehabilitation, regeneration and renewal thereby contributing to the economic recovery and fulfilling the objectives of reducing energy consumption, promoting clean energy and greenhouse gas reduction.

On 10th of September of 2013, the **Order FOM/1635/2013** was approved. This Order is the update of the basic document DB-I «Energy saving» (Documento Básico DB-HE «Ahorro de Energía») of the Spanish Technical Building Code (CTE - Código Técnico de la Edificación), approved by Royal Decree 314/2006, 17th March 2006. It concerns energy savings and partially transposes the following directives to the Spanish legal order:

- Directive 2002/91/EC and Directive 2010/31/EU of the European Parliament and of the Council of 19th May 2010, as regards the requirements for the energy efficiency of buildings, set out in articles 3, 4, 5, 6 and 7, as well as
- Directive 2009/28/EC of the European Parliament and of the Council of 23rd April 2009, as regards the requirement of minimum levels of energy from renewable sources in buildings, established in article 13.

Explicit consideration of this renewable technology, prioritizing its use in building with other renewable technologies, and its installation in public buildings (as the Directive requires to the public administrations) will certainly contribute to making this technology better known and used in Spain. In addition, the timely adoption of this European Directive would allow the Spanish industry to be directed in the direction indicated by the 2020 objectives of the smart cities and zero emission buildings.

Some days later, the Spanish Ministry of Industry, Energy and Tourism through the Institute for Energy Diversification and Saving (Instituto para la Diversificación y Ahorro de la Energía, IDAE) has implemented a specific programme to promote comprehensive actions favouring energy efficiency improvement and the use of renewable energies in the housing stock of existing buildings in the residential sector, and also to comply with article 4 of Directive 2012/27/EU, relating to energy efficiency. This programme, **PAREER Programme - Aid Programme for Energy Rehabilitation in Buildings in the Household and Hotel** Sectors - allocated with M€ 125, is estimated to be implemented all through October 2013 and October 2015. The actions are to fit one or more of the following typologies:

- Improvement of the thermal envelope energy efficiency.
- Improvement of energy efficiency in thermal and lighting installations.
- Replacement of conventional energy for biomass in thermal installations.
- Replacement of conventional energy with geothermal energy in thermal installations.

It is expected that the implementation of the PAREER Programme should have a favorable impact, both from the point of view of saving and energy efficiency improvement, and on the exploitation of renewable energies in the buildings of the Spanish residence and hotel sector.

From a technology perspective, the Spanish Strategy of Science and Technology and of Innovation and the State Plan of Scientific and Technical Investigation and of Innovation were approved in 2013, two relevant framework documents for the R&D Spanish community in the upcoming years. Both documents constitute the pillars on which the Spanish R&D policy is based. Both the Strategy and the Plan are aligned with Horizon 2020, which is the biggest EU Research and Innovation program, in order to boost the collaboration between Spanish and European entities in R&D projects. It must be highlighted that the instrument Technology Platform has for the first time been officially recognized by the Strategy, recognizing the relevant role of Technology Platforms in the promotion of R&D and, consequently, in the increase of competitiveness in a country. Besides, geothermal energy has for the first time been included as a scientific-technical and industrial priority of the Plan, which is strategic for the next future of geothermal technologies in Spain.

5. CONCLUSIONS

Traditionally ignored in Spain due to lacking information and knowledge, geothermal energy has experienced a certain come-back in recent years as a result of the emergence of new applications such as the use of heat pumps or the growth in general of the renewable energy market.,

This renewed interest has in parallel been reinforced - in the context of Directive 2009/28/CE and European efficiency criteria - by a new range of laws and national directives (particularly the 2011-2020 PER) setting objectives and figures for the sector and introducing some longer term perspectives for the Spanish geothermal sector in the 20/20/20 challenges scenario

Nevertheless, since 2011/12 the current crisis in the national construction sector coupled with the introduction of a strong set of indiscriminate legislative measures to strongly reduce the number of new RES appliances to enter the market pose, at present, a serious threat to our sector's ultimate takeoff.

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STANDARD TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2014	0		37,004		17,786		7,866			338,016*		1,012,023*
Under construction in December 2014	0											
Funds committed, but not yet under construction in December 2014	0											
Estimated total projected use by 2020	50	300	37,004		17,786		7,866			383,334*		1,006,913*

* Estimated 2015

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2014

Locality	Type[1)]	Maximum Utilization					Capacity[3)] (MWt)	Annual Utilization		
		Flow Rate (kg/s)	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow (kg/s)	Energy[4)] (TJ/yr)	Capacity Factor[5)]
			Inlet	Outlet	Inlet	Outlet				
Arnedillo	H+B	11	50	30			0.92	8	21.1	0.73
Fitero	H+B	8	52	30			0.73	5	14.5	0.63
Lugo	H+B	4	44	25			0.32	2	5.01	0.5
Ourense	H	5	75	30			0.94	4	23.74	0.8
Archena	H+B	10	45	25			0.96	6	18.2	0.6
Sierra Alamilla	H+B	8	52	30			0.74	5	14.51	0.62
Montbrió	H+B	15	42	18			1.5	10	31.65	0.67
Montbrió	G	6	78	25			1.33	3	20.97	0.5
Cartahgena	G	150	38	18			12.55	60	58.26	0.15
Zújar	G	10	45	20			1.05	4	13.19	0.4
TOTAL							21.04		221.13	0.33

H = Individual space heating (other than heat pumps), B = Bathing and swimming (including balneology), G = Greenhouse and soil heating

TABLE 4. GEOTHERMAL (GROUND – SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2014

Locality	Ground or Water Temp. (°C)[1)]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2)]	COP[3)]	Heating Equivalent Full Load Hr/Year[4)]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
Gandía (Azimut)	17.5	220	16	Hybrid	4.7	1,785	6.94	6.1
Suances (Cantabria)	13.5	100	12	V		1,120	3.15	2.97
Valencia (Complejo 9 Octubre)	18.5	186	35	V	4.21	2,004	5.87	5.3
Residencia (Jaén)	19	210	45	V	4.4	2,187	6.63	6.18
Castellar Oliverar	18.5	72	12	V	4.21	2,203	2.27	2.05
Centro de día (Benicasim)	17.5	185	15	Hybrid	4.37	1,355	5.84	4.92
Colegio Europa (Zaragoza)	15.5	97.2	15	V	4.17	1,237	3.07	
Basque Country	15	190	54	V	3.8	2,000	54.7	33.1
Basque Country	15	15	350	V	3.8	1,800	25.2	1.2
Basque Contry	15	12	150	H	3.2	1,800	8	
TOTAL			704				121.67	61.82

V= vertical ground coupled (TJ=10^{12} J), H= horizontal ground coupled, W= water source (well or lake water), O= others (please describe)

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES OF 31 DECEMBER 2014

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual Space Heating[4)]	3.52	76.26	0.686
District Heating [4)]			
Air Conditioning (Cooling)			
Greenhouse Heating	14.93	94.42	0.2
Fish Farming			
Animal Farming			
Agricultural Drying[5)]			
Industrial Process Heat[6)]			
Snow Melting			
Bathing and Swimming[7)]	2.59	52.5	0.642
Other Uses (specify)			
Subtotal			
Geothermal Heat Pumps			
TOTAL	21.04	223.18	

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	1	4		3		12-15
2011	1	4		3		10-12
2012	1	4		2		7
2013	1	4		1		4
2014	1	4		1		3
TOTAL	5	20		10		36-41

(1) Government, (2) Public Utilities, (3) Universities, (4) Paid Foreign Consultants, (5) Contributed Through Foreign Aid Programs, (6) Private Industry

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2014) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999						
2000-2004						
2005-2009	1.5		0.5	1	95	5
2010-2014	2		0.5	1.5	90	10