

# A Regulatory Roadmap to the Past, Present and Future of Geothermal Energy in Greece <sup>†</sup>

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**Abstract:** Greece is gifted with geologic features that promote geothermal heat flow. Geothermal energy exploration began in the late 60s, culminating in the first geothermal energy law in 1984 and the introduction of geothermal energy as a mineral resource under the amendment of the Greek Mining Code. Since then, low- and high-temperature geothermal activities followed their separate ways, with a modest utilization of the energy product in the primary sector (agriculture, aquaculture) and attempts for electricity production stalled since the mid-1990s. The adoption of green policies by both the EU and Greece, the acceptance of global warming as an existing threat, the adhesion to CO<sub>2</sub> reduction goals, energy efficiency and the application on renewable energy solutions as means to combat the increase in global temperature have led to an increasing interest in the utilization of the geothermal energy applications. This paper presents the new legal framework for geothermal energy established by Law 4602/2019, as introduced by the Greek Ministry of Environment and Energy, Directorate-General for Mineral Raw Materials and discusses its scope and goals set by the implementation of its provisions. The paper offers a roadmap to successfully test those new policies and regulatory provisions and, finally, it maps the interfaces of stakeholders and geothermal industry in an attempt to highlight the steps of the necessary administrative procedures towards the facilitation of viable geothermal projects.

**Keywords:** geothermal energy; regulatory framework; Greece



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## 1. Introduction

Geothermal energy is a non-stochastic form of renewable energy, with the lowest CO<sub>2</sub> footprint among other RES, fit for power generation and heating purposes depending on its energy potential. The presence of geothermal energy in Greece has been acknowledged as far back as the antiquity, mainly in the form of hot springs associated with medicinal use and recreational purposes. In recent years, Greece has been late, by comparison to other countries such as Italy, in exploring and utilizing her geothermal potential in an organized and effective manner. Exploration and exploitation were first regulated by Law 1475/1984 (Government Gazette vol. A, no. 113) while geothermal energy was classed as a mineral resource under the provisions of the Greek Mining Code. Later developments led to Law 3175/2003 and subsequent regulatory texts that served mainly the primary sector applications (agriculture, aquaculture, etc.), whilst attempts for electricity production were unsuccessful and were abandoned altogether in 1986. The need to update the legal framework in view of past shortcomings and new developments produced Law 4602/2019 (GG vol. A, no. 45). The new law introduces fresh concepts and sets a new regulatory framework which determines the roles, responsibilities and obligations towards a sustainable and rational use of geothermal potential in Greece.

Greece is undoubtedly characterized by significant high- and low-temperature geothermal potential due to favorable geological conditions. Despite the presence of good quality geothermal resources in a number of locations, geothermal use today remains limited to small-scale direct use applications such as greenhouse heating, agriculture crop drying and balneology. There is a few technical and non-technical matters that rendered cumbersome the development of industrial scale applications or more ambitious direct-use projects that could use this sustainable resource for electricity generation or urban heating. Such applications could significantly contribute to the renewable energy targets set by Greece and the European Union as well as safeguarding local energy security.

Technical matters refer to geological uncertainties and technical challenges faced upfront during the exploration phase and the resource development. Similarly, issues linked to reinjection of the geothermal fluids and chemical wear of wells require experience and long-term investment commitment. Those are some of the reasons why industry seems to have pursued other renewable technologies, whereby the initial CAPEX seems less risky, but they cannot undo their inherent stochastic character.

Non-technical matters are related to legal, financial and other supporting issues concerning the integration of the geothermal energy regulatory framework into the establishment of a coherent and farsighted policy dedicated to the management of geothermal resources. While there are a number of socio-economic and technical know-how factors that affect the poor performance of the geothermal projects, it is clear that sound and suitable regulatory regimes are important in the development of an energy sector that incorporates a much more widespread use of the geothermal potential than now.

## 2. Historical Perspective of Legal Framework

### 2.1. *The Early Years (1970–2003)*

Geothermal energy exploration began in the late 60s through programs initiated by academics and mainly the Greek Geological Survey, known as the Institute of Geology and Sub-surface Exploration (IGEY), later named the Institute of Geology and Mineral Exploration (IGME) and nowadays the Hellenic Survey of Geology and Mineral Exploration (EAGME).

As early as 1970, the Public Power Company (PPC), in partnership with IGEY and the assistance of the Organization for Economic Cooperation and Development (OECD), begun exploration field work that led to two (2) exploratory wells in the volcanic island of Milos in 1975–1976. In 1977, PPC invited ENEL (then the Italian state-owned energy company) into the exploration of new wells in 1981. Similarly, other areas came under more systematic field and laboratory investigations as early as 1971, such as the dormant volcanic structure at Sousaki [1]. Most of the exploration effort during the 1970s and 1980s focused on the identification of high enthalpy fields [2]. Following the encouraging initial results in Milos and Nisyros, PPC proceeded to deep wells and the development of geothermal fields in Lesvos and later in the Methana peninsula. IGME also proceeded into further studies in less costly lower temperature exploration projects.

The Greek Mining Code (Legislative Decree 210/1973, GG vol. A, no. 277) distinguished minerals in metal ores and quarry minerals and rocks. A core difference between the two categories lies with the nature of the ownership rights. Landowners' rights extend below ground surface only for those quarry minerals and rocks found within the surface boundaries of their properties, whereas the right to explore and exploit metallic minerals lies with the state, either leased by the state (public mines) or conceded via presidential decrees (concessions or private mines). Furthermore, there exists a sub-category of metal ores, the so-called "energy minerals" such as lignite, the exploration and exploitation right of which belong solely to the state and can only be leased.

Although the Mining Code included natural steam as a metallic mineral (article 2) as well as an energy mineral, it was not before 1984 that the term "geothermal potential" was introduced via Law 1475/1984 (GG vol. A, no. 113). It was the first albeit rudimentary attempt to define and regulate exploration and exploration rights and obligations, at a time where electricity production was a state monopoly under PPC. The law included

provisions on basic definitions such as “geothermal potential”, “geothermal energy”, and “hot water”. Geothermal potential was determined as any natural water with a temperature above 25 °C, earth naturally produced steam or geological formations’ heat. The public ownership of geothermal potential was solemnly confirmed in the law by reference to the related articles of the Mining Code. Furthermore, a privilege was established for public bodies, municipal enterprises, cooperatives and Greeks living abroad to become holders of exploration and exploitation rights without participating in a tender process. However, the Ministry later admitted [2] that the exclusion of private enterprise from geothermal projects led to considerable delay in promoting geothermal energy applications.

Other significant provisions of Law 1475/1983 included the authority of the Minister of Industry, Energy and Technology to resolve conflicts and the key terms of the lease agreements such as the initial lease period (15–30 years), the possible extension period (20 years) and a 30 percent share of the lease payment to the municipality where the geothermal field was located.

Following the provisions of the aforementioned law, four large and promising high-temperature geothermal areas (islands of Milos, Nisyros, Lesvos and later on the peninsula of Methana) were leased between 1985 and 2000 to PPC, the state-owned power company. PPC’s production attempts in Milos were abandoned by 1995 following strong local opposition caused by gas leakages, soon to be followed by Nisyros, where the local community became fearful of a similar fate.

Most medium-to-low-temperature basic exploration field work and production wells were carried out by IGME. Municipal authorities at that time were small in size and lacked the manpower and expertise to properly if at all carry out sophisticated duties, such as exploration and management of geothermal resources. However, IGME and other organizations such as the Hellenic Bank for Industrial Development (ETBA) and the Ministry of Agriculture, pressed on utilizing various state and EU investment tools (e.g., Valoren) and produced numerous wells mainly in Central and East Macedonia, Thrace and Lesvos island.

## 2.2. The 2003–2019 Period

Meanwhile, as EU energy policies started shifting towards the promotion of renewable energy sources to combat climate change and as the geothermal energy technologies advanced, it became obvious that the existing legal framework could not keep up with the developments. Law 1475/1983 was evaluated in the light of the structural changes in local government authorities, the failure to support the dynamics of geothermal energy by developing the potential of the promising high-temperature fields and the legislative gaps in implementation. Thus, in 2003 a new regulatory framework was introduced via the adoption Law 3175/2003 (GG vol. A, no 207).

The new law recognized that geothermal is a reliable and for the most part environmentally safe renewable energy source. According to the law’s explanatory report it was deemed necessary “to specify the framework for the leasing tenders of the rights to explore and exploit the geothermal fields and to clearly define geothermal energy as renewable and of common interest. This is necessary in order to enable the relevant projects to be included in the special favorable schemes for renewable energy sources in the EU”.

Although the new law insisted on the regulation of the geothermal exploration and exploitation activities by the general provisions of the Mining Code, it also made numerous breakthroughs and provided concise terminology for geothermal potential, fields, products, by-products and sub-products. Geothermal fields were categorized in relation to the product temperature as “high temperature” ( $T > 90$  °C) and “low temperature” ( $25 < T < 90$  °C). Another categorization emerged according to the characteristics of the fields as “proven” and “probable” the criteria of which were determined under the provisions of the Ministerial Decision D9B/F166/1508/GDNR374/10/27.01.2004 (GG vol A no 208). The term “geothermal field management” was also introduced and involved “all activities aimed at the productive extraction of geothermal fluid, the rational utilization of product and by-products, their

*distribution to third parties for all kinds of applications and the environmentally compatible disposal of sub-products”.*

The law bestowed the responsibility and management of the low-temperature geothermal fields to the regional governments and of the high-temperature fields, as well as the unexplored areas, to the competent authorities of the Ministry of Development (later the responsibility was transferred to the Ministry of Environment and Energy).

Moreover, a basic concept of the aforementioned law is that the geothermal exploration and exploitation rights are subject to a bidding procedure and not a direct award of the relevant contract to an interested party, for obvious reasons of transparency and public interest. Hence there were several provisions including the terms and rules of the competitive bidding procedures, the relevant contract terms and the general conditions regarding the duration of the lease agreements, the lease payments, the rights and obligations of the lessee, etc.

The subsequent regulatory Ministerial Decisions for both high- and low-temperature geothermal areas prescribed in detail the terms and conditions for declaring an area as a geothermal field, with either proven or probable characteristics, as well as the bidding procedures of geothermal potential exploration, production and resource management rights and the terms and conditions of the lease agreements.

In addition, the law set the framework for the licensing of heat-cooling systems that utilize the heat of surface geological strata and aquifers that do not represent geothermal potential (i.e.,  $T < 25\text{ }^{\circ}\text{C}$ ), better described as geothermal heat pumps systems and bestowed the responsibility of issuing the relevant licenses to the prefectures (and later to the regional governments). It also outlined the procedures for electricity and thermal energy production and distribution and foresaw the publication of a regulation of geothermal works. As dictated by the law, the first Regulation of Geothermal Works was approved and published in 2005. The Regulation formalized a set of general technical guidelines and conditions applied in exploration and production activities. Those rules had to be applied in conjunction to the already established environmental legislation, labor law, health and safety regulations and the existing Regulation of Mining and Quarrying Activities (KMLE).

The following years more than forty proven and probable geothermal fields were characterized with the combined efforts of IGME and the competent authorities of the regional governments and the Ministry which led to the development of primary sector applications in agriculture (e.g., green house, drying), aquaculture, etc., mainly in the regions of Central Macedonia, East Macedonia–Thrace and to a lesser extend in the islands of Chios and Lesbos. Additionally, two proven high-temperature geothermal fields suitable for electricity generation in the islands of Milos and Nisyros were characterized.

Meanwhile, following the restructuring of elected local government authorities, known as the Kapodistrias reform (Law 5339/1997, GG vol. A, no. 244), another administrative reorganization took place in 2010, known as the Kalikrates reform (Law 3852/2010, GG Vol. A, no. 87). The reform turned the 13 appointed regions into the second tier of elected local government and the amalgamation of the existing municipal and communal authorities into 325 larger municipalities. The decentralized arm of the state formed seven (7) appointed decentralized administrations (DAs) that have since overseen the regions’ actions and carried on administrating several local issues, including those of low-temperature geothermal energy. Licensing of non-geothermal potential heat-cooling systems remained with the elected regional authorities.

During the period 2011–2013, while the efforts for developing the high-temperature geothermal areas that belonged to the PPC SA were continued—without tangible results—by PPC Renewables S.A., a wholly owned subsidiary of Greece’s power generation company as a result of a transfer of the relevant rights, several international bidding rounds took place on granting exploration rights on 8 unexplored areas (Samothraki isl., Chios isl., Nestos river delta, Evros river delta, Sousaki, Ikaria isl., Spercheios valley, and Akropotamos at Kavala). The above rounds, although produced preferred bidders, did not materialize into contracts mainly due to overbidding and changes in fiscal security as Greece

entered a long period of financial and credit difficulties. The non-success of the bidding procedures in combination with the failure of the PPC corporate move to improve the already poor record in geothermal exploration resulted in a “geothermal hiatus” and hence the quest for electric power generation by harnessing geothermal energy remained an uncertain prospect in the years to come.

As for the low-temperature geothermal framework, despite the efforts of IGME and the decentralized administrations, there was limited progress mainly in Central–East Macedonia and Thrace, while other regions with proven and probable potential were inactive due to minimal interest. During this period, the Centre for Renewable Energy Sources (CRES or KATIE) actively communicated the concept of geothermal pumps and pursued the expansion of use and development of heat-cooling systems.

The assessment of all the above failures and problems reported by the competent authorities signaled the time for an update of the geothermal legal framework, in order to keep up with the needs and challenges of the socio-economic landscape.

### 2.3. The New Law 4602/2019

Since 2010, the gradual adoption of green energy policies in the EU, as well as transformations in the Greek administration and industry, led to the need to encourage geothermal energy applications in a sustainable and environmentally responsible manner [3]. The experience gained during the unsuccessful high-temperature bidding rounds, the inadequacies in exploring and exploiting the geothermal potential of the four high-temperature areas by PPC Renewables S.A., as well as numerous recorded problems that surfaced while managing low-temperature fields and contracts, brought about the need to revisit the geothermal legal framework. In 2016, a committee was set about to see how the regulation framework may become friendlier to operate and more effective in promoting the geothermal industry. Thus, Law 4602/2019 (GG vol. A, no. 45) came into play following a 3-year incubation process. In practical terms, Law 4602 does not deviate from the previous framework, but it attempts to modernize it and provide a stable platform for inviting new investment.

This law redefines terms and concepts in all related matters and sets a new improved regulatory framework which determines the roles, responsibilities and obligations towards a sustainable and rational use of geothermal potential in Greece. The main axes of the law include:

1. A change in the categorization of geothermal fields. More specifically, the geothermal fields are now considered as “of local interest” (temperature  $30\text{ }^{\circ}\text{C} < T < 90\text{ }^{\circ}\text{C}$ ) and “of national interest” (temperature  $T > 90\text{ }^{\circ}\text{C}$ ). In addition, the new term “Areas of Geothermal Interest” is introduced relating to the wider areas in which there are indications that geothermal potential of temperature up to  $90\text{ }^{\circ}\text{C}$  is present.
2. The minimum temperature for determining the potential in geothermal fields of local interest is increased by  $5\text{ }^{\circ}\text{C}$ , thus releasing the utilization of several agricultural wells for irrigation.
3. The right of exploitation is separated from the management right. The definition of management right clearly indicates that it refers to the whole geothermal field.
4. The responsibility for the exploration, exploitation and management of geothermal potential in fields of national interest and unexplored areas belongs to the Minister of Environment and Energy whereas the respective rights concerning geothermal fields of local interest and Areas of Geothermal Interest are managed by the DAs which take on important management responsibilities.
5. The duration of the lease of the exploration right in the unexplored areas is set up to five years with a possible extension period of two additional years and up to three years with a possible extension period of one more year, in case of geothermal fields of local interest and Areas of Geothermal Interest. Accordingly, the lease period for the management and exploitation right of the geothermal fields of both national and local interest is up to thirty years, which can be expanded to twenty additional years.

6. Exploration and exploitation can co-exist in case geothermal potential is detected during the exploration period.
7. A simplified procedure concerning the leasing process of the potential in geothermal fields of local interest is introduced. In case of an interested party application, the relevant authority issues a public invitation for an expression of interest, lasting 30 days. If there is no interest whatsoever the initial application is evaluated and the relevant right is leased. In case interest is expressed by other parties, a bidding procedure takes over.
8. If the utilization of the geothermal potential is for the purpose of covering the thermal needs of primary and secondary schools, as well as health centers and hospitals, there is no obligation for a lease payment or a letter of guarantee for the due performance of the contract terms.
9. The decentralized administrations are obligated to publish development plans every five years in order to ensure the rational use and the protection of the natural resource within the areas of their responsibility. Furthermore, there is a provision for the establishment of committees for the utilization of geothermal potential and water management in order to address relevant challenges.
10. The critical role of the Hellenic Survey of Geology and Mineral Exploration (EAGME) in local field exploration, resource management and documentation is specified. Emphasis is given to the survey's cooperation with the Ministry of Environment and Energy (MoEE) and the decentralized administrations to support the management responsibilities within the geothermal fields.
11. There are provisions regarding the establishment of registers and portals in both the MoEE and EAGME to utilize all the available geothermal information and data and monitor the relevant activities.

Details for most of the above issues will be determined by ministerial decisions and joint ministerial decisions, until the geothermal legal framework is complete and ready to be implemented. A major step toward this goal and more specifically to assist the promotion of geothermal exploration and production was the elaboration of a new Regulation on Geothermal Works.

### 3. Regulation on Geothermal Works

The Regulation was completely rewritten between 2019 and 2020 by a committee of experienced academics, research and field practitioners as well as competent authorities' staff that handled exploration, drilling technology, HSE, production contracts and resource management issues. Following intense research in relevant codes and practices from countries with significant geothermal production and similar legal system, the Committee also utilized the accumulated local low-temperature geothermal experience, tested practices from the oil and gas industry and the HSE framework as set by internationally accepted standards, EU and national law.

The new Regulation on Geothermal Works consists of 27 articles, divided into 4 chapters and 7 indexes. The Regulation was approved by Ministerial Decision ΥΠΕΝ/ΔΑΡ/42138/552/29.04.2021 (GG, vol. B, no. 1960), and came into force on the 14 May 2021. It provides unambiguous definitions on all important items and aspires to provide a hand-in-hand guide to exploration and production procedures in chapter B for national interest fields and unexplored areas, as well as in chapter C for local interest fields and areas of geothermal interest.

In either cases and in an effort to reduce bureaucracy, the Regulation provides detailed lists of contents that the lessee should follow in the preparation of exploration work-programs that are submitted to the lessor prior to any such activity. The lessor no longer grants approval of the submitted document, but rather checks the adherence to the specific work program list of contents and provides a statement of no objection. Particular attention is placed on the details of a drilling program submittal. The Regulation requires the production of health and safety manuals for the various types of exploration works and

emergency response plans in particular for deep drilling operations. The lessee's only document required for approval by the lessor is the production technical report. However, it should be stressed that there may be other documents subject to approval as required by the applicable environmental, labor, etc., legislation.

The Regulation details the drilling operations and the obligations of the lessee during the exploration phases, the abandonment of a well, and it specifies the contents of a well's daily diary and record. It also describes the production/exploitation works, including pump tests, the measurements taken, the requirements for the necessary equipment and their acceptable accuracy levels. Likewise, the Regulation details the lessee's obligations in facilitating the sustainable management of the geothermal resources.

Apart from the purely geothermal activities, in chapter D, the Regulation sets the general obligations of the lessee. It spells out the environmental protection prerequisites and obligations with particular reference to emergencies or accidents. In order to limit disturbance caused by exploration and production works and installations, the Regulation establishes minimum distances from neighboring activities, installations, various utilities networks and buildings. Health and safety rules, legislation and codes are listed for easy access. Additionally, chapter D provides rules and obligations on HSE measures for activities near power or other sensitive or dangerous networks, e.g., electricity, exposure to chemical agents and work inside enclosed or restricted areas, e.g., troughs, pits, containers, silos. Finally, the Regulation sets rules and places great importance to the documentation produced, in order to safeguard that important data is not lost. Primary data ownership belongs to the lessor, while the lessee can enjoy the copyright by generating secondary data through elaboration or processing.

#### **4. On the Bidding and Leasing Procedures and Processes**

##### *Ministerial Decisions on the Bidding Procedures for the Lease of the State's Rights to Explore, Exploit and Manage the Potential of the Geothermal Fields*

Alongside the Regulation on Geothermal Works, the aforementioned Committee elaborated on the regulatory framework of the bidding procedures for both national and local interest geothermal fields. The draft of a ministerial decision on the terms and procedure for the lease of the state's right to explore, exploit and manage the potential of unexplored areas and the geothermal fields of national interest entered into public consultation in December 2020, in order to ensure that all stakeholders can provide their input.

The provisions of the draft ministerial decision do not drastically change the previous regulatory landscape on geothermal energy, as they follow the general rules set by Law 4602/2019 combined with some of the prerequisites and terms of the legal framework on public procurement. In this context, the new framework rather offers remedial changes, as an attempt to attract investment, without endangering the viability of the resources and the protection of public interest.

The focal point is to make a clear and structured bidding and contracting manual for the potential investor in order to know exactly how to participate in the open tender procedure, what to expect and, most importantly, what the agreement terms and conditions are.

As mentioned before, the exploration rights in an unexplored area are leased through an open tender procedure which can be initiated either by an interested party or by MoEE. The whole process is described in an invitation to public tender document, elaborated by the competent authority, which includes the invitation to bid, the instructions to bidders, the general conditions of the lease agreement and other technical specifications.

In general, participation in the tender is open, on equal terms, to those parties that meet the legal, financial and technical requirements set in by the invitation document and can demonstrate the required professional adequacy and relevant experience. There are certain grounds for disqualification from the tender procedure that are on a par with the general provisions of the public procurement processes. The eligible bidders are invited to submit a sealed folder containing a sub-folder with the participation supporting documents

and a second one with the exploration program as well as their environmental, financial and technical qualifications.

All applications are evaluated by the Tender Committee which is established by the decision of the Minister of Environment and Energy, on the basis of the evaluation criteria as set by the Law 4602/2019. These criteria include the amount of expenditure for exploration within the leased area and, in particular, concerning the minimum exploration work program, the type of exploration works, their gradual development in connection with the works execution time and the time when expenditure is made, together with the ability to implement environmental management, the proven technical experience and financial ability to meet the required obligations. Any lack of efficiency or responsibility displayed by the bidder in relation to obligations under previous projects should be taken into account by the Committee.

On this occasion it should be noted that one of the key changes introduced by the provisions of the ministerial decision is the division of the exploration program in two phases, following the standards of oil and gas exploration activities. The first phase carries the exploratory work necessary to identify a geothermal source and determine its properties. The budgeted cost of this phase is an important biddable item and hence is backed in full by a bank guarantee. This is a motivation to the bidders to design and price their first phase based on science, value engineering and weighted risk assessment. An important difference compared to the previous regime is that the amount of the bank guarantee (euro commitment corresponding to the estimation of the minimum work exploration program) is reduced by an amount equal to the expenditure made by the lessee depending on the progress of the program. This reduction is facilitated by a ministerial decision following a documented request made by the lessee.

The second phase contains only additional exploration items that could be realized based on the findings of the previous phase. This exploratory phase is not mandatory but optional, as it heavily depends on the results of the minimum work program, nevertheless, is evaluated as a competition criterion and is backed up by a financial guarantee if it eventually takes place.

Another important element concerns the negotiation process presented for the first time in the geothermal regulatory framework. Applicants who are found to be both technically and financially qualified are invited to enter into negotiations on the basis of the biddable items and specifically the minimum work program, the financial guarantee (euro-commitment) and the supplementary work program (the second exploratory phase). Negotiations can be an extremely useful tool for evaluating and improving the bids as it infuses the bidding process with a more dynamic perspective.

In general, when the tender procedure is over, the successful bidder is invited to appear before a notary public in order to sign a formal agreement, the lease contract. The contract must necessarily have the form of a notarial deed, signed by the appointed representatives of the competent agency and the successful bidder. It includes all the terms and conditions described in the tender declaration document and the relevant legal framework, as well as the obligations undertaken by the successful bidder.

Depending on the results and the data acquired upon the completion of the exploratory work program, if a geothermal field is certified as of national interest (i.e.,  $T > 90$  °C), the lessee is invited to submit a feasibility study for the exploitation/management of the geothermal potential. The study is evaluated and if deemed accurate, viable and adequate, the exploitation/management right is granted and a relevant lease contract is signed. It should be noted that according to the previous provisions, when signing the exploitation lease contract, the lessee was obligated to submit a bank guarantee equal to 3% of the value of the related works and installations which was then replaced by the letter guarantee for the due performance of the contract terms upon the start of the production. The new provisions include only the letter bank guarantee which is submitted when the contract is signed.

Furthermore, the provisions of the draft ministerial decision include the lessee's rights and obligations, the lease payments, the monitoring of the lease contract terms and the related sanctions, the concession of the rights, and the termination of the contract.

A similar ministerial decision is under elaboration by the competent Directorate of MoEE regarding the terms and procedure for the lease of the right to explore exploit and manage the potential of the geothermal fields of local interest and areas of geothermal interest (i.e.,  $30\text{ °C} < T < 90\text{ °C}$ ). This decision will include provisions similar but more on the simplified leasing procedures of the potential in low-temperature geothermal fields. The aim is to encourage geothermal investment at a local level, with applications that will support local production potential and restore public confidence in the use of this alternative form of energy. The basic structure that discerns between exploration and exploitation still holds for local interest geothermal fields. Depending on the available data and past history, the competent DAs may initiate an exploration tender process or go for an exploitation (production) tender process. The steps are more or less akin to the above described ones. Unlike the national interest fields, an interested party may apply for the exploitation right to a particular local interest field. This procedure enables investor's initiative to be generated at will. Depending on the viability, the general added value for the state of the proposed investment scheme and the integrity potential investor, the competent authority may proceed to an open invitation for more bids. The outcome of such an invitation will eventually conclude to an exploitation lease agreement.

## 5. Next Regulatory Framework Acts

In addition to the above described texts, the Law 4602/2019 prescribes the elaboration of other texts that detail procedures and processes on important supporting issues such as financial or fiscal incentives on investments, the contents of the quinquennial Geothermal Potential Development Plan reports on local interest geothermal fields and areas of geothermal interest drawn by each DA, the creation of interactive databases in the Ministry and EAGME to support informed decisions by the state or potential investors, the terms and conditions for licensing heating–cooling energy systems that exploit the non-geothermal potential of ground strata and surface aquifers (via geothermal heat pumps), concurrent issues with spas and medicinal baths, etc.

### 5.1. Geothermal Potential Development Plan and Annual Account Reports

This is a new type of report drawn and approved by each competent DA on a quinquennial basis (5 years). It aims to be a useful tool that spells out a medium-term planning for the development of geothermal potential in local interest geothermal fields and areas of geothermal interest. Those reports will be reviewed by EAGME for technical evaluation and once approved they are displayed on DA's and the MoEE's internet sites. The Law 4602/2019 requires that DAs should also include plans of action for the expansion of areas where geothermal potential exploitation may take place and report on changes to the available potential per area or field. This new reporting comes along with the annual obligation by each DA to report to the MoEE on the previous year's account on exploration and the exploitation of geothermal potential within their areal jurisdiction. The procedures and the data required for the production and dissemination of those two types of reports will be the subject of a separate ministerial decision.

### 5.2. Heating and Cooling Energy Systems—Geothermal Heat Pumps

Those systems are earth-coupled, ground-source, or water-source heat pumps known as Geothermal Heat Pumps (GHPs), sometimes referred to as GeoExchange, locally also known, albeit incorrectly, as shallow geothermal systems. They utilize the thermal capacity and constant temperature that does not constitute geothermal potential (i.e.,  $T < 30\text{ °C}$ ), of near surface geological strata and/or the surface aquifers as the exchange medium instead of the outside air temperature. They have been in use since the late 1940s [4]. The licensing of such installations and other technical and environmental issues is regulated

by a ministerial decision that, although it works, needs upgrading to the new geothermal framework and other related laws. The MoEE in collaboration with CRES and other institutions will serve this need as a matter of priority, given the potential of those energy applications to the 2030 national energy goals.

### 5.3. Incentives

The question of elaborating ministerial decisions that create new or provide access to existing financial or fiscal tools and incentives is a complex one. It should be noted, however, that although Law 4602/2019 applies to all matters related to the exploitation of the geothermal potential, it has little to do with the processing of the geothermal product into thermal or electrical power, its distribution and the authorizations required. Thus, any incentives or such tools require the collaboration of the Regulatory Authority for Energy (RAE) and the Ministry of Finance.

This is an issue primarily linked to high-temperature or deep geothermal related exploratory drilling as it carries a forward risk in capital expenditure before the final result is known. This risk is similar to the oil and gas industry, however, if successful, the investment recovery is slower by comparison. Additionally, the HSE requirements during operations may add to the burden of concerns in an investor's calculations. That, in some investors' mind, may be a disadvantage by comparison to solar or wind farms that have a fraction of a cost in exploration and a smaller risk in countries like Greece. However, geothermal energy is not a stochastic source of power and that should be a counterbalance, provided that short term thinking is not present. The mere notion of Italy's and Turkey's performance on developing geothermal resources [5] is an indication that stable, long-term production is an asset worth risking. Hence, the effort should be directed to create incentives that ameliorate derisking, by helping potential investors to use tools such as insurance policies that may hedge against failed or less productive exploration campaigns. Other incentives may be initiated by the state's acknowledgment that geothermal power generation contributes to the national energy basis and could provide energy stability by supporting local interconnections between certain island groups. For instance, the state could ensure, as in Germany in 2016 [6], that geothermal power generation stays in feed-in tariffs when all other forms of RES have entered the target model scheme. Incentives may be the kick start factor for more municipalities to seek and pursue local geothermal solutions for urban heating. Other fiscal, financial or tax related incentives may already exist by existing development funds and laws and may have already been enjoyed by some investors; however, there is a need to bring such initiative together in order to formulate a base tailored to the particular needs of geothermal potential exploration and exploitation.

Other incentives may include the installation of heating-cooling energy systems, especially in non-geothermally rich mountainous areas and parts of Northern Greece which may not be related to other national, or EU funded general energy efficiency initiatives. For example, since 2017, the German government provides a grant for new heating technologies by the market stimulation program (MAP). The rules of the MAP changed a couple of times in the past (amount of the grant, type of technologies, grant for new and/or existing buildings). Since 2015, very good conditions for the installation of geothermal heat pumps were established [7].

### 5.4. Databases and Online Information

Law 4602/2019 foresees the creation of two compatible databases in the Ministry of Environment and Energy and EAGME, respectively. The National Registry of Geothermal Utility Focii is a gateway that shall reside within the MoEE internet site. Its purpose is to collect, maintain, process and present in a GIS environment, technical, contractual and administrative information related to geothermal fields and areas of geothermal interest around the country. The Registry is linked to relevant databases in EAGME and the Centre for Renewable Energy Sources (CRES) and receives relevant data from the DAs and regional authorities. Once in operation, the gateway will become the central and compulsory point

of publicity about any geothermal act or action related to the implementation of Law 4602/2019. EAGME shall create and maintain a Registry of Documentation and Monitoring of all geothermal spots and monitoring stations (including hot springs) and a database of the geothermal wells constructed or about to be constructed by the survey as part of its activities, or any such information by third bodies associated to EAGME. EAGME shall construct and maintain an internet gateway, where all the available geospatial data and geothermal monitoring results are presented in a GIS environment. The publicly available information will abide by the legislation that protects sensitive data. The details on the characteristics and the available services provided by the above gateways shall be determined be a ministerial decision.

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