



Study on risk insurance schemes, with corrective measures

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Authors: Spyridon Karytsas¹, Ioannis Choropanitis¹, Dimitrios Mendrinou¹, Constantine Karytsas¹, Attila Kujbus², Annamária Nádor³, Beata Kępińska⁴, Aleksandra Kasztelewicz⁴, Maciej Miecznik⁴, Bogusław Bielec⁴, Christian Boissavy⁵, Philippe Dumas⁶

Authors' affiliations: 1. Center for Renewable Energy Sources and Saving (CRES), 2. GeoEX Ltd., 3. Mining and Geological Survey of Hungary (MBFSZ), 4. Instytut Gospodarki Surowcami Mineralnymi i Energią PAN (IGSMiE PAN), 5. AFPG / GEODEEP, 6. EGEC

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Executive summary

Several European countries have significant untapped geothermal energy potential. However, to utilize geothermal energy on a much broader scale in the future, it is not enough to have a geothermal resource as an exploitation target, but it is also necessary to introduce suitable non-technical support measures, including tools aiming at mitigating potential geothermal projects' risks. The most important one is the resource risk, which can create financial risks for the projects' developers and operators.

Risk insurance funds for geothermal projects have already been operating in specific European countries (i.e., France, Germany, Iceland, The Netherlands, Denmark, Switzerland, and Turkey). Nevertheless, except for these countries, project developers have limited capability to manage this financial risk. Thus, the EU-funded GEORISK project aims to promote Risk Mitigation Schemes (RMS) all over Europe, as well as in some third countries, to cover risks associated with the development and the operation of deep geothermal projects.

On this basis, the project aims to promote the establishment of new geothermal RMS in three target countries, namely Greece, Hungary, and Poland, with a prospective geothermal potential. The three countries' geothermal markets can be characterized as juvenile ones or in transition at best, so until now, the main development support tools consist of public grants and loans, hence no RMS have been established in them until now.

In this context, D(4.4), "Study on risk insurance schemes, with corrective measures", presents particular aspects for the RMS establishment in the three target countries, in terms of: a) the main geological and geophysical conditions; b) the relevant legal aspects; c) ten-year operational and financial simulations, to examine the financial sustainability of proposed schemes; d) corrective measures performed, with the goal of initiating a national RMS; e) a list of potential deep geothermal projects for the following ten years in each country.

All three countries hold significant geothermal potential, either for heat or power generation, with each one presenting its particular geological characteristics and levels of geothermal exploration. Hungary is already well-explored, meaning that an assumption of a 90% project success rate is valid since only EGS projects carry a high risk. On the other hand, the particular geology of Greece has created more diverse geothermal conditions, with the exploration of the high-temperature resources being rather limited. Thus, a project success rate of 90% can be assumed for explored fields, while the corresponding rate for insufficiently explored fields could be assumed to be around 67%, or even lower. As for Poland, the diverse geostructural

elements have led to different geothermal conditions. Based on these conditions, the success rate of potential projects can be assumed to be, in general, approximately 80%.

The legal basis for establishing an RMS was mapped for each country, having in mind that none of them have launched such a scheme until now. Thus, the legislations and policies that can become the foundation of such schemes were identified and presented. Among the three target countries, Hungary is the most advanced in introducing an RMS, probably during 2021. This has already been well-grounded at a policy level through the new National Energy Strategy and the National Energy and Climate Plan, with both documents mentioning the Geothermal Guarantee Fund. In Greece's case, the National Energy and Climate Plan (2019) includes a section on "Risk factors and challenges" for RES, acknowledging the importance of risk mitigation and -generally- proposing the use of relevant tools. Additionally, a mention could be made to Greek Law 4602/2019 which generally references incentives for geothermal energy development support. Likewise, the main legislative and policy documents that could put forward or reference a Polish geothermal RMS include a) the Environment Protection Law, which sets a legal basis for establishing geothermal public financial support, b) the electricity-focused Act on Renewable Energy Sources which verifies the State's involvement in supporting RES market uptake, and c) the Polish Energy Law and Poland's Energy Policy until 2040, in the context of proposing the utilization of targeted RMS.

The financial sustainability of a presumed RMS in each country was evaluated through the conduction of ten-year simulations, based on specific parameters (i.e., the number and nature of expected projects, the initial designated capital, the operational costs of the scheme, the level of insurance premium and risk coverage, and the expected success rate). The results of the simulation, when taking into account specific insurance premium (10%) and risk coverage (75%), are the following for the three countries:

- The Hungarian RMS (90% success rate assumed) is financially sustainable and could continue its operation even after the ten years, having lost only 4% of its initial capital during this period;
- Depending on the success rate, the Greek RMS (success rate assumed: 50-75% for unexplored high-enthalpy fields; 90% for all explored fields) could take a range of different outcomes; from a "collapse" after six to eight years, up to financial sustainability exceeding the ten years;
- The Polish RMS (80% success rate assumed) is financially sustainable for the ten years, with the fund's capital depending on the amount of implemented projects within

this period; however, the results show that after this period, it would probably require an "injection" of capital, as it would have lost around 25 to 40% of the initial capital.

These estimations were made on a common basis of insurance premium and risk coverage. This means that the identified deviations between the three countries mainly result from the different levels of projects' success rates (thus being RMS sustainability's most sensitive factor), which in their turn result from the different levels of geothermal exploration in each country. However, the importance of the additional factors should not be overlooked.

Based on the above financial analysis and under the presented technical and legal aspects, it is evident that establishing an RMS in all target countries is both meaningful and feasible. On these terms, several activities have been performed in this direction within the GEORISK project, including identifying key-stakeholders, communication of the project and its results, exchanging information, and collecting opinions and feedback, all in the context of promoting the geothermal RMS initiation.

Accordingly, Hungary is highly advanced in introducing a new RMS, probably within 2021. Greece is in the process of developing an RMS proposal, as the Ministry of Environment and Energy has shown interest in initiating such a scheme. Poland's goal is to include the proper paragraphs and provisions into existing legal and regulatory documents, such as the Law of Environment Protection.

1. Introduction

Several European countries have significant untapped geothermal energy potential, especially for space heating, and to some extent, for electricity generation. However, to utilize geothermal energy on a much broader scale in the future, it is not enough to have a geothermal resource as an exploitation target, but it is also necessary to introduce suitable non-technical support measures. These measures should include tools aiming at mitigating potential geothermal projects' risks (for a detailed list of potential risks, refer to GEORISK D(2.1) "Risk register" and D(2.2) "Report on risk assessment"), with the most important one being the resource risk, which can take the form of:

- The short-term risk of not finding an economically sustainable geothermal resource after drilling;
- The long-term risk of the natural depletion of the geothermal resource, making its exploitation economically unprofitable.

Until the first well drilling, developers cannot be sure about the planned geothermal project's exact main exploitation parameters (temperature and flow rate), which define the economic performance of the investment. However, once drilling has been performed, in situ pump tests, temperature, and hydrological measurements reduce the resource risk and make it possible to attract external capital not previously offered due to the high uncertainty.

Risk insurance funds for geothermal projects have already been operating in specific European countries, namely France, Germany, Iceland, The Netherlands, Denmark, Switzerland, and Turkey (for a full assessment of past, ongoing, and planned Risk Mitigation Schemes (RMS) in Europe and worldwide, see GEORISK D(3.1) "Existing insurance schemes"). Nevertheless, except for these countries, project developers have limited capability to manage this financial risk.

The EU-funded GEORISK project (Developing geothermal projects by mitigating risks with financial instruments) aims to promote RMS all over Europe, as well as in some third countries (including Canada, Mexico, Chile, and Kenya), to cover risks associated with the development and the operation of deep geothermal projects. On this basis, the project aims to promote the establishment of new geothermal RMS in three target countries, namely Greece, Hungary, and Poland, with a prospective geothermal potential.

The three countries' geothermal markets can be characterized as juvenile ones or in transition at best, so until now, the main development support tools consist of public grants and loans.

Following these markets' expected development, additional -initially public-type- supportive tools seem necessary. Thus, it should be emphasized that discussions with various stakeholders and proposals to decision-makers are ongoing in several countries to introduce such tools. These supportive tools include risk mitigation schemes tailored to each market's maturity level and are suitable for the three target countries mentioned above. However, until now, no such schemes have been established in these countries.

In this context, D(4.4), "Study on risk insurance schemes, with corrective measures", reports the technical, legal, and financial aspects of the three target countries' potential risk insurance schemes. Specifically, the deliverable presents:

- The main geological and geophysical conditions in each country, setting particular conditions for the RMS establishment (Section 2);
- The legal aspects related to the establishment of an RMS in each target country (Section 3);
- Ten-year operational and financial simulations for each country, to examine the financial sustainability of proposed schemes (Section 4);
- Corrective measures performed in each country, with the goal of initiating a national RMS (Section 5);
- A list of potential deep geothermal projects for the following ten years in each country, used for the performance of the simulations mentioned above (Annexes I, III, and IV).

The information presented in this report could be valuable in establishing a national RMS in the three target countries. Additionally, the ten-year simulation results could be helpful from a broader perspective for potential investors, decision and policymakers, financial institutions, and insurance companies.

2. Technical aspects

2.1. Greece

Hydrothermal resources in Greece are located in areas of Quaternary or Miocene volcanism areas and continental basins with high heat flow. High temperature (>200°C) resources have been confirmed tapped in Milos (150 MWe potential) and Nisyros (50 MWe potential) islands, while also indicated in Thera (Santorini) Island, based on the active volcanic activity. Numerous low temperature (<100°C) reservoirs have been detected in other locations, utilized mainly for balneology and/or greenhouse/soil heating. Additionally, potential deep medium temperature resources (100-200°C) have been identified by drilling exploration in Sousaki, the Nestos River Delta basins, Xanthi-Komotini, and Alexandroupolis basins, as well as in Samothraki and Lesbos islands [1]. Moreover, potential medium temperature resources are inferred by geothermometers and volcanic outcrops in the Xanthi-Komotini and extended Sperchios River basins, and Samothraki, Chios, and Lesbos as well as in Sousaki and Chios islands [1].

Based on the above exploration results, the most suitable geothermal areas for power generation are sites located on the active Aegean volcanic arc (Milos, Nisyros, and Santorini islands; potentially Kimolos and Kos islands, Methana and Sousaki), on North Aegean islands with Miocene volcanism (Lesbos, Chios, and Samothraki), and sedimentary basins in northern Greece (Nestos River, Xanthi-Komotini, and Alexandroupolis) [1].

Moreover, numerous shallow to relatively medium depth (i.e., 0-2.000m) geothermal resources are located across Greece. Information on each field's depth, temperature, flow rate, TDS (Total Dissolved Solids), and type is available in detail in the GEORISK project's D(2.4) "Study on technical measures".

Geothermal exploration in Greece commenced in 1970. It was mainly carried out by the Public Power Corporation (PPC) of Greece for the medium-high temperature (100-350 °C) resources, up to 2 km depth, for power generation and by the Institute of Geological and Mineral Exploration (IGME) – now the Hellenic Survey of Geological and Mineral Exploration (EAGME) – for the low temperature (<100 °C) resources, up to 600 m depth, for agricultural applications. Except for Milos and Nisyros islands, it should be noted that limited data is available for the medium and high-temperature reservoirs mentioned above, as no or limited geothermal drilling exploration has been carried out, while in many cases, estimated reservoir temperature values have been calculated by geothermometer analysis.

2.2. Hungary

Hungary is located at the heart of the Pannonian Basin, which has remarkable geothermal potential, expressed through raised heat flow density (range: 50-130 mW/m²; mean: 90-100 mW/m²) and a geothermal gradient of around 45 °C/km [2][3][4][5]. This condition resulted from the Early-Middle Miocene extensional formation of the basin: the lithosphere stretched and became thinner, and the hot asthenosphere approached the surface [6].

The so-called "Upper Pannonian" thermal aquifer represents the most advantageous porous geothermal aquifers, also known as basin-fill reservoirs. These aquifers are located in a depth range of 700-2.000 m, with temperatures extending between 60 and 90 °C [5][7][8][9]. Also, it should be noted that hydraulic connections exist between the regional aquifer layers, thus leading practically to consistent hydrostatic pressure within the entire sedimentary series.

Moreover, it is worth mentioning that the carbonate and crystalline rocks present in the Pannonian Basin's basement might also function as potential geothermal reservoirs. They are also called basement reservoirs and store a significant amount of thermal water [10], and their temperatures can exceed 100–150 °C (at the basement depth, i.e., at around 2.000 m or more) [11].

Apart from the above, a mention should be made to the Hungarian high-enthalpy reservoirs related to a) deep-lying (3.500-4.000 m) overpressured fractured rocks (dolomites) and b) deeply-embedded granitoid rocks with elevated in-situ rock temperatures (> 200 °C) and favourable seismo-tectonic conditions promising future EGS (Enhanced Geothermal Systems) project developments.

The main geothermal reservoirs can be grouped in line with the officially delineated thermal groundwater bodies used in the National River Basin Management Plans, based on lithological types, hydrogeological characteristics, flow directions, chemical types, and other hydrogeological parameters. The main parameters (depth, temperature, flow rate, TDS, and type) on each reservoir are available in the GEORISK project's D(2.4) "Study on technical measures".

2.3. Poland

Three central geostructural elements shape the Polish area from a geological and tectonic perspective, namely a) the Paleozoic platform of Western Europe, b) the Precambrian platform of Eastern Europe, and c) the (Outer and Inner) Carpathians. It is worth noting that the diverse

geostructural elements, evolution, and age resulted in the differentiation of Poland's thermal and geothermal conditions [3]. Generally, the heat flow varies between 20-90 mW/m² and the geothermal gradient between 1-4°C/100 m.

According to the geostructures mentioned above and their different characteristics, a distinction can be made between different Polish geothermal units, in particular, a) the Polish Lowlands, b) the Inner Carpathians, c) the Outer Carpathians, d) the Carpathian Foredeep, and e) the Sudetes Region.

At this point, it should be emphasized that geothermal water resources in Poland are of low-temperature and mainly related to two provinces, the Polish Lowlands being the largest and most prospective, and the Inner Carpathians (the Podhale region). These regions are related to the so-called deep geothermal applications, which in Poland refers to wells / geothermal water aquifers and fields located several hundred meters below the ground level. Following this statement, some essential information can be provided for each of the five central geothermal units.

In the Polish Lowlands, the geothermal waters are held by Mesozoic sedimentary formations, comprising the porous aquifers. Geothermal flow rates may exceed 300 m³/h, while monitoring of current operations has shown overall stability of the flow rates during production. Outflow water temperatures range between 20-97°C (depth up to 3.5 km) for exploited or tested wells, while measured/predicted temperatures of unexploited aquifers range between 120-130°C (depths around 4 km).

In the Inner Carpathians (Podhale region), the main geothermal aquifers are hosted by Mesozoic (mainly Triassic) limestones – dolomites. Geothermal water flow rates (artesian conditions) may reach 550 m³/h. Outflow water temperatures range between 28-87°C (depth between 1-3.7 km) for exploited wells, while measured temperatures of deeper –poorly recognized- aquifers may reach 120°C (depths around 4.8 km).

In the Outer Carpathians, the geothermal waters are hosted by locally flysch sandstones, being porous, sometimes secondary porous/fractured aquifers. Geothermal water flow rates stretch up to 40 m³/h. Outflow water temperatures of exploited wells range between 24-40°C (depths up to 1 km), while measurements of up to 84°C (depths around 4 km) have been taken from currently unexploited cases.

The Carpathian Foredeep's geothermal waters are hosted by Tertiary sandstones or Mesozoic and Palaeozoic sandstones and carbonates of its older basement. Measured and predicted

flow rates are usually below 20 m³/h (except for the Cenomanian aquifer, up to 250 m³/h), while measured and predicted temperatures range between 20-120°C.

In the Sudetes region, geothermal waters are hosted in the fractured parts of crystalline and metamorphic formations. Measured and predicted flow rates may reach several dozen m³/h, while outflow water temperatures range between 20-87°C.

The main reservoir parameters (depth, temperature, flow rate, TDS, and type) are available in the GEORISK project's D(2.4) "Study on technical measures".

3. Legal aspects

3.1. Greece

Currently, there is no geothermal RMS available in Greece. Nevertheless, for low-temperature resources (<100 °C) it should be mentioned that possible exploration and geological risks are reduced for potential investors through the exploration activities performed by the Hellenic Survey of Geology & Mineral Exploration (EAGME) throughout the Greek geothermal fields. Besides, municipalities develop infrastructure for district heating networks, utilizing funds from the European structural funds through the National Strategic Reference Framework (NSRF) of Greece; thereby, risks related to lack of funding for geothermal exploration and field development are mitigated.

There is also a feed-in-premium tariff system enforced for geothermal power generation, mitigating the market risk of geothermal power plant investments. According to this system, the electricity sold by geothermal power plants to the power grid receives an additional premium to the achieved sold price, to reach the reference price of 104 €/MWh for plants of capacity >5 MWe or 134 €/MWh for plants of capacity up to 5 MWe [Ministerial Decision ΥΠΕΝ/ΔΑΠΕΕΚ/30971/1190 published in Government Gazette 1045B' of 26.03.2020]. This system is equivalent to a feed-in-tariff system with these electricity unit prices, which are valid since the 1st of January 2021.

Moreover, a mention should be made to the National Energy and Climate Plan (NECP), issued by the Ministry of the Environment and Energy (2019). The NECP includes a section on "Risk factors and challenges" for RES in general, which a) acknowledges the importance of risk mitigation; b) proposes the use of preferential loans through special funds; c) proposes the provision of insurance for initial collateral damages of loaning schemes. Thus, this could create a basis for the introduction and establishment of geothermal-focused RMS in Greece.

Further on, it is essential to mention Greek Law 4602/2019 concerning the research, exploitation, and management of the country's geothermal potential. The Law includes an article referring to incentives for geothermal energy development support without mentioning specific incentive types. Against this background, RMS could be proposed as one of the potential incentives/ support measures. Additionally, it should be mentioned that the Ministry of Environment and Energy has initiated a Committee in the context of the Geothermal Law's implementation. Specific funding schemes have been proposed during this committee's works,

specifically grants plus subsidized interest loans for the exploratory and development phases of high and low enthalpy geothermal energy.

Other than that, additional Laws, Ministerial Decrees and Reports exist, which are not directly related to the initiation and development of an RMS, but address various social, financial, environmental, and technical risks of geothermal projects' exploration, development, and operation, like those being reported in GEORISK's D2.1 "Risk register". Likewise, various regulations and documents either provide recognized geothermal fields' technical information (location, surface, temperature, depth, flow rate) or set the rules to collect it. The availability of this information is critical for the establishment of an RMS, as it can provide technical input, while it can also reduce the potential technical failures by providing specific information for each specific field.

3.2. Hungary

Among the three target countries, Hungary is the most advanced in introducing a new RMS, most probably during 2021. This has already been well-grounded at a policy level through the January 2020-issued new National Energy Strategy and National Energy and Climate Plan. Both documents specifically mention the Geothermal Guarantee Fund; the first step of this scheme will be developing pilot projects, with the experience gained through these projects providing feedback to improve the RMS specifications further.

The Hungarian RMS proposal suggests geothermal projects' eligibility both for electricity and heat production by thermal water abstraction, applying full reinjection, a min. depth of 1000 m, using only conventional technologies (EGS projects are not supported within this scheme). According to the scheme, drilling activities will be supported via ex-post-financed tenders by investment risk mitigation, partial sharing of investment risk, and introduction of collateral for failure coverage. The details of the Guarantee Fund are currently under governmental discussion among the relevant ministries.

These advancements are built on a sound basis; the Action Plan on the Utilization and Management of Energetic Mineral Resources [Governmental Decision 1345/2018. (VII.26)] set the task of composing a proposal to mitigate high upfront risks for geothermal projects by introducing financial tools by June 2019. Responsible for this task were the Minister for Innovation and Technology and the Minister for Finances. Moreover, it should be noted that the Action Plan mentioned above has a strong background, as, since 2012, the Mining and Geological Survey of Hungary (and its legal predecessors) have prepared numerous studies

on the various Hungarian geo-energy resources –also including geothermal energy, in terms of their potential, possible future utilization, etc. Altogether, there is no question that the expected establishment of the Hungarian Geothermal Guarantee Fund is the outcome of a 10-year deliberate effort made jointly by the associated ministries, the national geological survey, and the leading geothermal operators.

Apart from the above, a mention should be made to additional regulatory pieces of high importance, categorized into two groups. The first group consists of the Act of Mining and related governmental and ministerial decrees, mainly related to the concessional procedure, applying to the exploration and exploitation of geothermal resources below 2500 m depth). The second group incorporates the Act on Water Management and related governmental and ministerial decrees concerning groundwater resources (hence, geothermal aquifers) and the protection and management of their quality and quantity. Thus, these legislative items include numerous provisions concerning the assessment of data from the aquifers (namely, yield, temperature, abstraction amounts, fluid chemistry, reservoir dimension), providing essential technical parameter inputs for future schemes.

3.3. Poland

Until now, no geothermal risk insurance fund exists in Poland. Anyhow, there are numerous national-level laws, acts, and provisions regulating geothermal-related activities in Poland. The main legislative items relevant to geothermal RMS are a) the Geological and Mining Law; b) the Environment Protection Law; c) the Energy Law; d) the Water Law; e) the Act on Renewable Energy Sources; f) the Building Law.

Among them, a mention should be made to the Environment Protection Law, which sets a legal basis for establishing geothermal public financial support (Article 400a § 1, 22, in specific). Drawing from this, the National Fund for Environment Protection and Water Management (NFEP&WM) has launched in the several last years, various geothermal support programs.

In this regard, it should be noted that three major state programs were initiated in the last few years (2016-2020), applying grants and loans for geothermal development's support. The mentioned programs are a) "Geology and Mining; Part 1) Recognition of Geological Structure of the Country and Management of Mineral Deposits and Ground Waters" (2016-2023), "Polish Geothermics Plus" (since July 2019), and c) "Abstraction of geothermal waters in Poland" (2020-2025).

In the absence of more targeted provisions, these support programs have functioned to some extent as geothermal RMS in the early investment stages of a relatively juvenile market. This is the case for non-repayable grants (up to 85-100% for local government units) for first exploration or research geothermal wells: if the drilling results would not be the expected, the beneficiaries of these support schemes would bear no consequences and economic risk, being covered by the public entity (government) granting this support. However, the well (unsuccessful from a geothermal point of view) is treated as a source of new geological information. Hence, from the point of view of the entity (government) providing this support scheme, in both cases (either successful or unsuccessful wells, from a geothermal point of view) the public grants bring a positive effect.

Against this background, and based on the lack of a Polish Risk Insurance Fund for geothermal projects, it stands to reason to propose the establishment of a geothermal RMS tool (in the form of a risk insurance fund) that will complement and expand the scope of the Environment Protection Law.

Moving on from the Environment Protection Law, a mention should be made to the electricity-focused Act on Renewable Energy Sources. The act, which verifies the State's involvement in supporting RES market uptake, could be employed to either put forward provisions on targeted RES RMS –needless to say, including geothermal energy- or making reference to RMS provisions included in other legislative documents.

On top of that, it is worth acknowledging the Energy Law focused on Poland's energy policy presentation. Although not currently including any geothermal RMS-related provisions, this legal piece could introduce such support tools in the future. This sort of addition could verify the State's support towards RES development.

Shifting from legislative items to strategy and energy policy documents, it is purposeful to address Poland's Energy Policy until 2040 (Apr 2020 version considered). The document should consider the provision or recommendation of targeted RMS (including geothermal energy) as essential instruments for the development of RES (including geothermal energy) and achievement of set targets.

Either way, any of the above-proposed additions to the existing legislation or policy must be developed with cooperation between the relevant policymakers/ministries and be harmonized from thereon. Such work could be performed in parallel with the formulation of a proposal on a Polish risk insurance fund.

4. Financial aspects: Simulations for the target countries

4.1. Objective

The financial simulation's main objective is to calculate the cash-flow for a proposed RMS for ten years. To determine the cash-flow, the operation actions affecting it must be determined. Since the actions mentioned above depend on the particular national conditions affecting the characteristics of the RMS, the simulation process proceeds accordingly by:

- Determining the legal forms, the targeted risks, and the operating forms of the RMS;
- Deciding on the range of insured projects and geological structures;
- Specifying the RMS assumptions, including the insurance premium, the risk coverage, and the estimated success rate;
- Calculating the scheme's fixed costs, such as initial costs, overhead, operational, and project evaluation costs.

The following step involved the detection of planned projects for the next ten years, which was done within GEORISK's Task 4.2, "Support establishment of an insurance scheme in target countries". It should be noted that since future deep geothermal projects have not been planned yet in detail, most of the applied data are based on representative estimations of exploitation scenarios in well-known geothermal reservoirs.

After the determination and calculation of all these inputs, the simulations can be performed. The key parameters affecting the cash-flow can be determined either in the scope of making its operation financially sustainable or in the context of estimating the funds required for financial support for the ten years' operation.

4.2. Initial approach

Following this process, a ten-year risk mitigation scheme was drafted, including a description of the projects' activities and annual cash-flows. It should be mentioned that although being an estimation, it illustrates a realistic operation of the RMS.

To design an RMS fitting each target country's specific needs and characteristics, input was collected by relevant national-level key-stakeholders. In this context, two questionnaires were

distributed to stakeholders during the conduction of the performed National Workshops (see Task 4.2, "Support establishment of an insurance scheme in target countries") to collect their opinions and ideas related to the establishment and operation of an RMS. The input collected through these questionnaires facilitated the decisions made regarding the potential RMS types, targeted geological structures, available contract types, and RMS key-parameters. Based on this input, the assumptions on the insurance premium, risk coverage, and estimated success rate were adjusted to realistic values for each target country.

The first draft scheme was shaped using the Hungarian assumptions and inputs of fixed costs while averaging project data. The fixed costs, the costs of the projects' evaluation, the revenues from insurance fees, and the payments to the unsuccessful projects altogether provide the ten-year cash-flow. Based on this input and assumptions, it was possible to perform sensitivity analyses on a) the insurance premium, b) the success rate, and c) the risk coverage.

After this initial analysis, simulations were performed for the three target countries, i.e., Hungary, Poland, and Greece. Additionally, it should be emphasized that the presented simulation model may serve as a template for any country that intends to establish an original and financially sustainable RMS.

4.3. Performing the first set of simulations

The first simulation was performed based on the Hungarian case. To make this first approach as straightforward as possible, the cash-flow was calculated based on average project data, while a basic risk-coverage scenario was applied: 30 projects in 10 years; 10% insurance premium; 75% risk coverage; 90% estimated success rate.

This first simulation results in a financially sustainable RMS model, as presented in Figure 1. In any case, it should be noted that this case is ideal –after all, a 10% insurance premium is relatively high, so the next step was to conduct a set of sensitivity analyses by varying the RMS key-parameters.

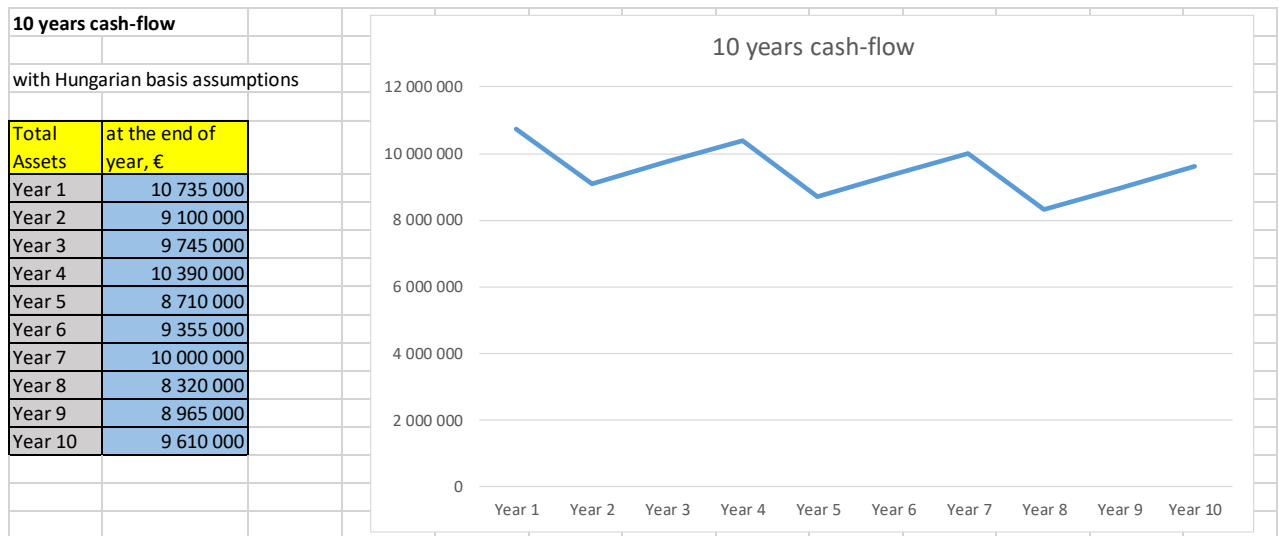


Figure 1. The Hungarian case with average project data and basic scenario.

The first sensitivity analysis targeted the identification of the effect of a range of different insurance premiums on the RMS model, keeping in mind that the paid premium strongly influences the RMS financial sustainability. The results of this analysis are presented in Figure 2. Based on the presented results, a 10% premium appears to be sufficient for the scheme's sustainable operation. In contrast, if the insurance premium is set to 4% or less, the scheme requires public funds' financial support on a ten-year basis. This result emphasizes that the definition of the premium rate level is a strategic decision of high importance.

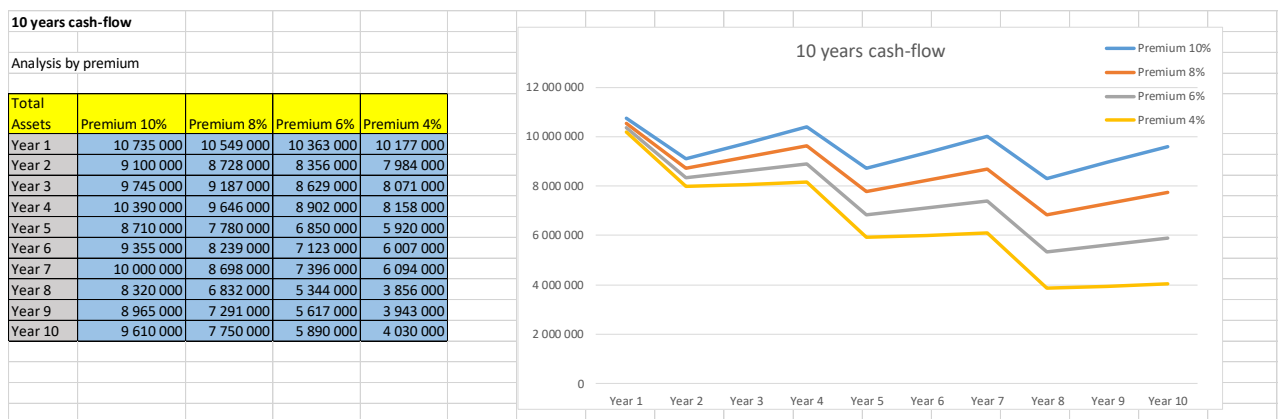


Figure 2. The Hungarian basic scenario: Sensitivity analysis on insurance premium parameter.

The following sensitivity analysis focused on the effect of the risk coverage on the scheme's cash-flows. The results of the analysis are presented in Figure 3. It should be mentioned that the risk coverage level is a fundamental parameter, not only for the scheme's viability but for the project developers as well. Essentially, the projects are insured up to this percentage of

their capital costs, and the investors place the additional capital at their own risk. Thus, it concerns a predominantly technical issue related to technological solutions costs.

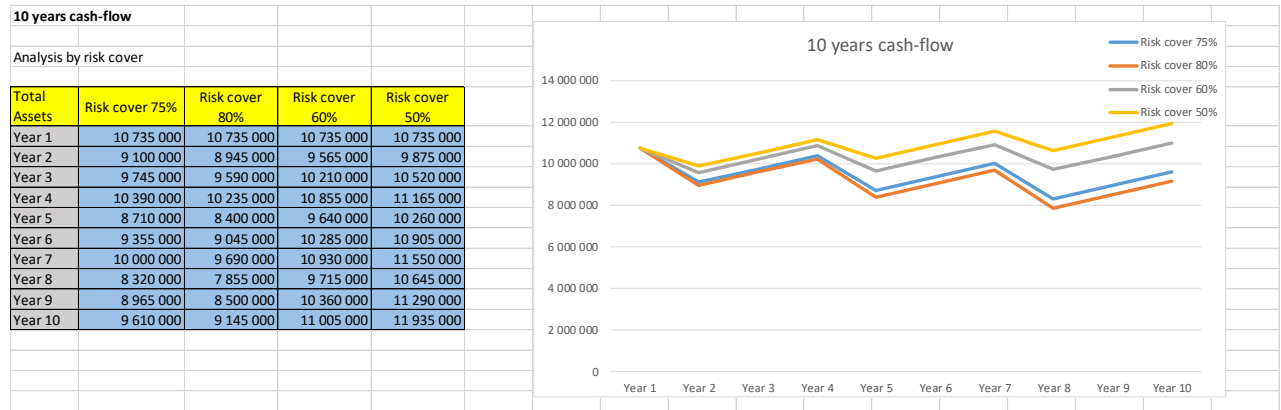


Figure 3: The Hungarian basic scenario: Sensitivity analysis on risk coverage parameter.

The third sensitivity analysis was dedicated to the examination of the success rate's effect. The analysis's results are presented in Figure 3. As anticipated, the specific parameter is the most sensitive one. Thus, it is worth highlighting that a strategic target is to maintain the success rate above 90% (i.e., one out of ten projects is deemed to fail) in the interest of achieving the financial sustainability of the scheme. This means that a success rate lower than 90% will most likely require regular public funding for the RMS.

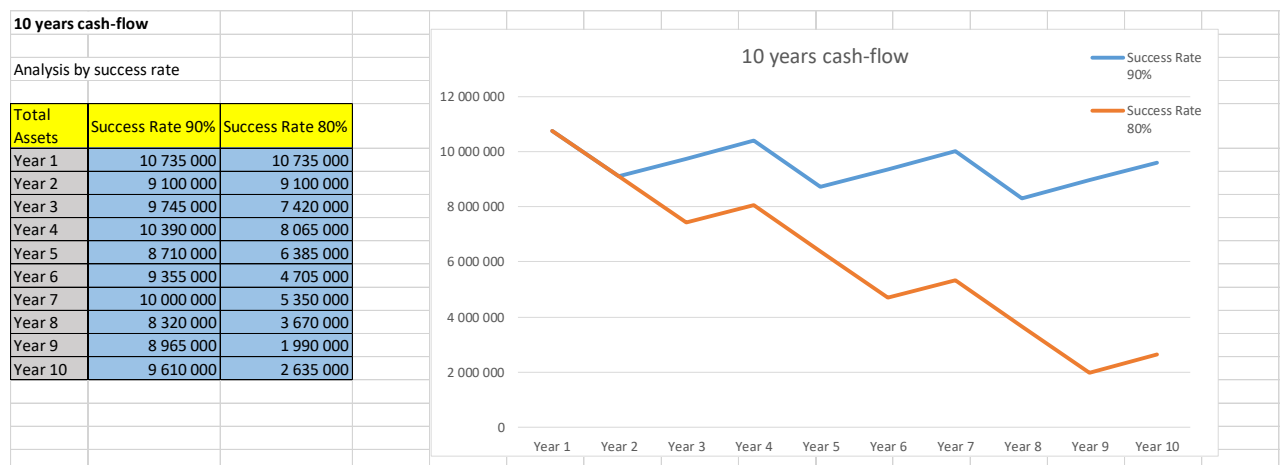


Figure 4: The Hungarian basic scenario: Sensitivity analysis on success rate parameter.

After performing the first set of simulations, based on Hungary's initial assumptions, the following step of the simulation process is to perform a respective analysis for each of the three

target countries, with reference to their expected projects and their particular legal, financial, and technical backgrounds.

4.4. Greece

Greece's geological conditions have resulted in numerous geothermal fields, corresponding to a significant geothermal potential. Still, its exploitation is limited, as it is used exclusively for low enthalpy (<90 °C) direct heat uses, while there is a complete absence of electricity generation plants. Therefore, a potential RMS goal should be to "unlock" private geothermal sector investments, especially for medium (100-150 °C) and high-enthalpy (>150 °C) applications.

So far, at least 55 geothermal fields have been identified in Greece, located across the country. Nonetheless, it should be noted that the level of their exploration may vary significantly. National legislation recognizes geothermal resources proven by wells tapping their reservoir; these resources refer to two high-enthalpy (>300 °C) ones (Milos and Nisyros islands) and several low-enthalpy fields (<90 °C), located mainly in Northwest Greece.

Based on the described conditions, the conducted simulation handles each potential project's estimated success rate differently. Thus, the starting success rates taken into consideration are 90% for high-enthalpy proven fields (Milos and Nisyros), 67% for high-enthalpy unexplored fields (Chios, Lesbos, Methana, Sousaki, Samothraki, and Thera), and 90% for proven low enthalpy fields (Akropotamos, Aristino, Erasmio, Erateino, Heraklia, Nea Kessani, Nigrita, Sidirokastro).

The development scenario assumes drilling, completion, and operation of one successful doublet in each of the above high-enthalpy fields for power generation and three successful doublets in each of the above low-enthalpy fields for district heat supply. A number of failed wells are also considered based on the above success rates. Drilling costs were estimated based on local geologic and reservoir conditions; the estimates are somewhat conservative, corresponding to the lower part of the cost spectrum. Each insured project is comprised of either one production or reinjection well.

The Greek ten-year simulation was performed based on a scenario involving the drilling and completion of 55 production or reinjection wells in the fields mentioned above (see Annex I). The corresponding success rate was taken into account in each case, while the insurance fund's initial capital was set to € 10 million. Against this background, the ten-year cash-flow was assessed based on different insurance premium (8, 10, and 12%) and risk coverage (65, 75, and 85%) combinations.

Figure 5 depicts the corresponding results of the nine different combinations. It is worth mentioning that when considering the specific success rates set above (90%/67%/90%), under all circumstances, the insurance scheme is financially unsustainable for all selected premium and coverage pairs. This is represented by the total assets' balance negative-slope trend line in all cases. Nevertheless, a distinction should be made between the cases where the scheme still has remaining funds to operate after the ten years, compared to the cases where the scheme has financially "collapsed" before the ten-year mark.

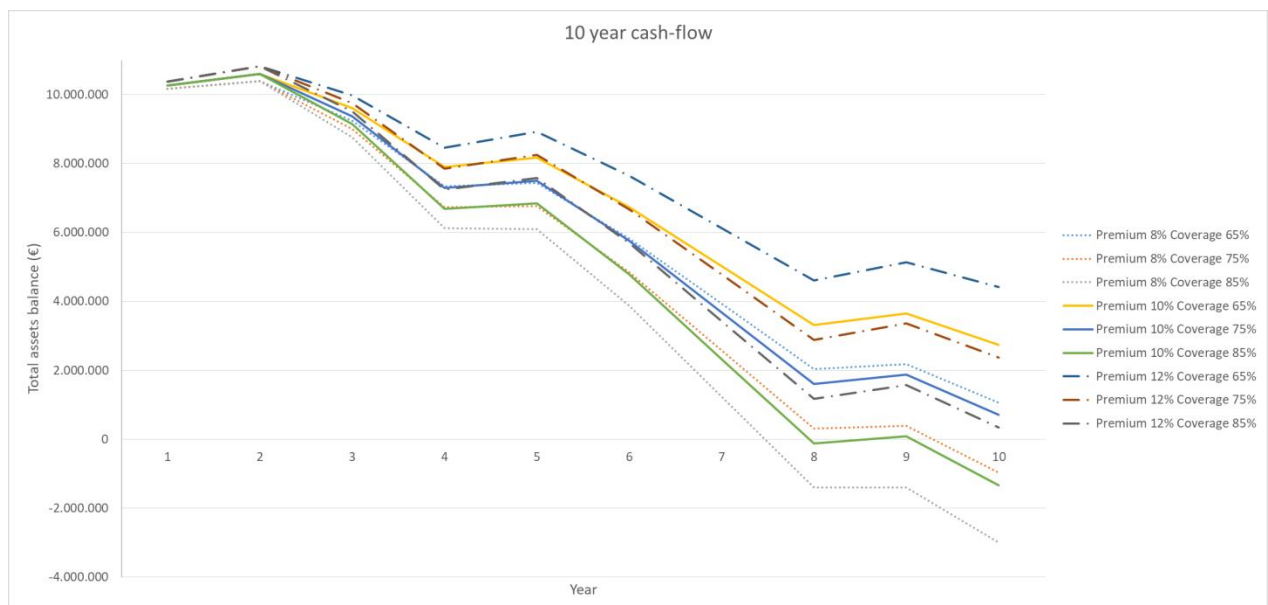


Figure 5. The Greek case: scenario of drilling and insuring 55 wells in the next 10-year period; success rates 90% for high-enthalpy proven fields, 67% for high-enthalpy unexplored fields, 90% for low-enthalpy fields.

After examining different coverage rates' and insurance premiums' effects, the next step included evaluating projects' different success rates' impact on the developed scenario's ten-year cash-flow. Given this, four cases were prepared: the three of them maintained the same 90% success rate for all high-enthalpy and low-enthalpy proven fields and different success rates (50% - 67% - 75%) for the high-enthalpy unexplored fields. The 4th scenario assumed that geothermal developments would only occur in proven fields, referring either to high-enthalpy (Milos and Nisyros) or low-enthalpy fields, with the corresponding success rate set at 90%. In every scenario, premium and coverage rates were held constant, 10% and 75%, respectively.

Unquestionably, the projects' success rate plays the most crucial role regarding the insurance scheme's financial sustainability. As illustrated in Figure 6, an overall 90% success rate scenario could be considered financially sustainable, with a remaining capital of approximately € 9,9 million after ten years of operation (yellow-colored line). In contrast, a 50% success rate scenario for the high-enthalpy presently unexplored fields would probably drive the scheme to a financial collapse after seven years of operation (blue-colored line). By all means, it is essential to note that the particular cash-flow progression in each scenario is affected by the specific years that the projects are presumed to fail, based, of course, on the corresponding success rate. This means that setting –in the context of the simulation- different years for the failed projects could result in different cash-flows, which would nevertheless lead to the same final result (i.e., financial collapse) within ± two years.

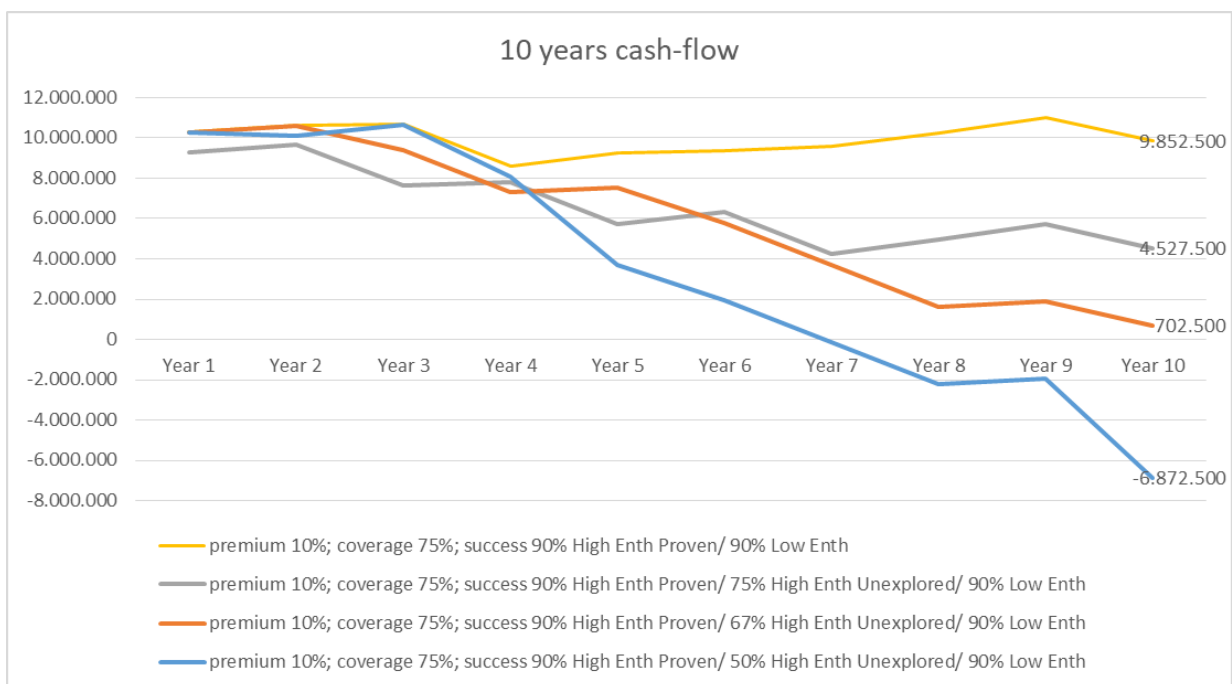


Figure 6. The Greek case: effect of different success rates on the 10-year cash-flow.

According to the analysis presented above, some preliminary results can be pointed out. It has been already mentioned that a € 10 million scheme (10% premium; 75% coverage; 90%/67%/90% success rates scenario) would not be financially sustainable, seeing that after ten years of the fund would contain less than € 1 million. Still, that kind of scheme would be meaningful to be set in motion in the form of a public fund under a ten-year geothermal development policy for Greece. Moreover, if the insurance premium (10% in the examined

case) is seen as relatively high to be covered by private developers, a 50% public subsidization of the premium could also be introduced as a policy measure towards geothermal development. Such a public scheme [€ 10 million + 50% premium subsidy (i.e., 5% premium in the specific case)] would lead to significant leverage of public investment towards geothermal development, equal to 6,21. This result is calculated taking into account that based on the considered scenario, € 83,65 million of total funds will be mobilized, using € 10 million public funds plus € 4,1825 million premium subsidization minus € 0,7025 million residual funds after ten years.

Suppose the objective is to launch a private fund based on the parameters described in the above paragraph. In that case, a premium not less than 21% should be applied to maintain at least financial sustainability (i.e., the fund being approximately € 10 million after ten years of operation) (see Annex II). In such a case, and bearing in mind that private investors would generally accept a premium up to approximately 5%, the public would have to subsidize the extra 16 percentage points (to reach a 21% premium) in terms of a geothermal market acceleration policy. In this situation, € 13,384 million of public funding would trigger € 83,65 million of private investments in geothermal projects. Thus, a leverage of 6,25 would be accomplished, i.e., approximately the same level as the public fund proposed above. In any case, the 21% premium would be sufficient only to reach the profitability threshold, which means that *ceteris paribus*, a private scheme would require a higher premium to operate.

It is worth noting that different preconditions concerning the premium, coverage, and success rates would result in different financial requirements and outcomes regarding the establishment of a public or a private fund, either assisted or not by a public risk premium subsidization scheme.

4.5. Hungary

Hungary is a well-explored country with more than 8.000 hydrocarbon and about 1.000 geothermal wells and a wide coverage of various geophysical measurements, especially 2D and 3D seismics. Thus, enough geological and geophysical data are available to conduct a relatively detailed regional and local underground analysis. This means that only extremely deep (i.e., in the 5-6 km range) EGS projects could be characterized as high-risk projects.

Moving on, to perform the ten-year simulation for Hungary, based on the expected projects (see Annex III), the following assumptions were considered for the RMS, following stakeholders' opinions: a) all deep-geothermal projects are included; short-term contracts,

including drilling and testing wells; b) all possible geological structures are eligible; c) preferred contract type involves a grant, subsidized premium in advance, fee post-financed.

The scheme's initial capital was set to € 10 million, while total overhead costs were estimated to be 150.000 €/year and expert costs per project to be 30.000 €/year. The scheme's operating costs include the fund's, secretariat's, technical committee's and the experts' costs (see Figure 7). Thirty expected projects were selected for the ten-year simulation. Since these projects' exact costs and planning are still not fully available, the simulation was performed based on realistic project data estimations. It is evident that the simulation results (Figure 8) are similar to the Hungarian basic scenario case (see Section 4.3), given that the key-parameters are the same: 10% insurance premium; 75% risk cover; 90% estimated success rate. Thus, further analysis based on the key parameters' variation was not performed; the corresponding results are presented in Section 4.3, as performed for the Hungarian case applying average project data. In any case, it is worth noting that under these specific circumstances, there is an opportunity for the establishment and operation of a financially sustainable RMS.

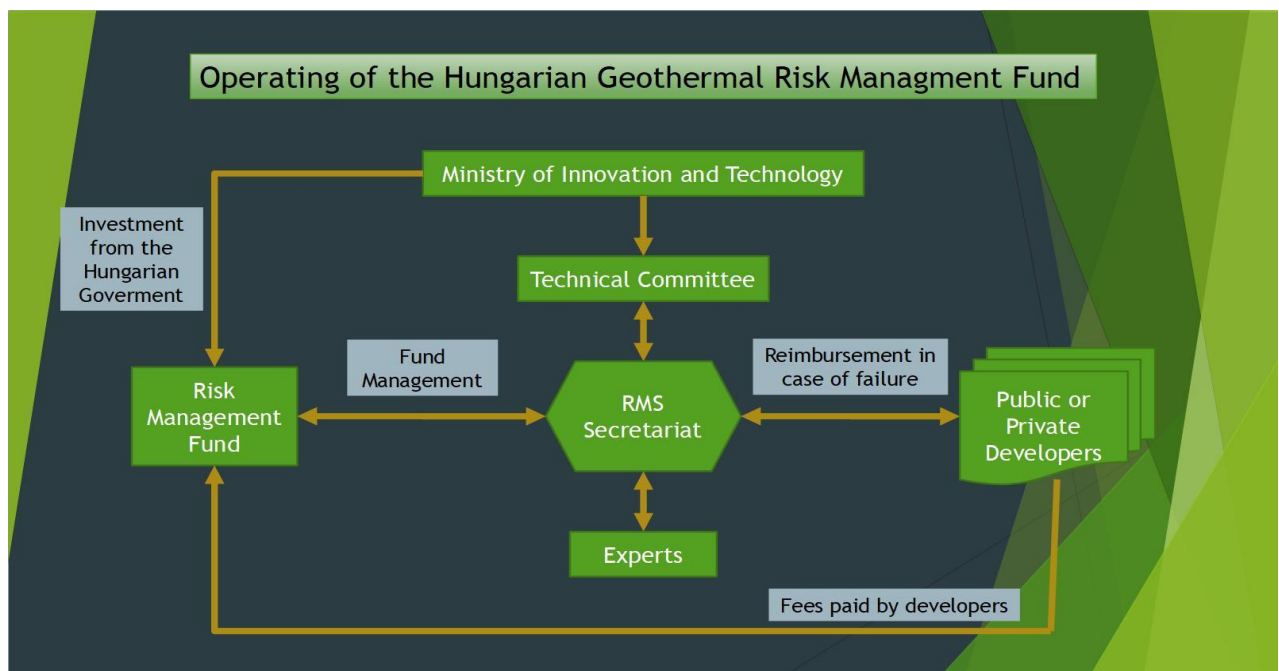


Figure 7. The recommended operation of the Hungarian geothermal RMS. The draft operating chart of the planned RMS is similar to the French system under operation.



Figure 8. The Hungarian case with the expected realistic 30 projects in the following ten years.

4.6. Poland

Following representative available information (e.g., [12]) in the coming decade 2020-2030, the drilling of as many as 40 to 60 geothermal wells can be expected in Poland (Annex IV). They would serve various purposes, like district heating, heating, and other direct applications. Nevertheless, it should be noted that some drillings and subsequent investments, especially those aimed at geoDHS (geothermal District Heating) and heating, will be implemented only if non-repayable public grants are awarded.

As previously mentioned (Section 3.3), since 2016, various public priority programs offering such forms of support have been launched, including Geology and Mining (since 2019), Polska Geotermia Plus (since 2019), Accessing Geothermal Waters in Poland (since 2020), FM EEA Constructing Heat Sources Using Geothermal Energy (deep geothermal) (since 2020). However, in the following years, local governments, being the primary beneficiaries and implementers of geoDHS' projects, will probably not be interested in the geoDHS' development in the case that no public non-repayable grants (taking over the financial risk from entrepreneurs in case of unsuccessful drilling and not finding the proper geothermal resource) are available.

Considering this possible situation, respectively, 20 and 30 of the overall identified potential projects (see Annex IV) were assumed as a basis for conducting the ten-years operation simulation, given that they will not be eligible for public support in the form of non-repayable grants, thus being financed in other forms and from other sources. In such a case, a public risk

insurance fund is a suitable tool for these projects' de-risking, being attractive for other potential investors (including private ones) interested in entering the geothermal heating market.

The ten-year operation simulations were performed based on the following assumptions, which are the most likely to occur based on the present geological and economic conditions and the current Polish geothermal heat market status:

- Initial capital: € 11,28 million, estimated as three times the average cost of drilling a geothermal well, based on the value of drilling projects qualified for public non-repayable grants and loans (average depth approximately 2.606 m);
- Number of insured wells: 20 and 30 respectively, within the ten years;
- Success rate: 80%, leading to 4 and 6 unsuccessful wells, respectively;
- Insurance premium: 4, 6, 8 and 10%;
- Risk coverage: 70% and 75%;
- Timespan of each project: 3 calendar years;
- Annual RMS overhead costs: € 150.000;
- Expert cost: € 10.000 per ongoing project, annually.

The simulations were performed taking also into account the French and Hungarian experiences and assumptions (Section 4.5). The proposed RMS operation results are presented in Figures 9 and 10, for 20 and 30 covered projects, respectively (for detailed also see Annex V). In the vast majority of the produced cases, the fund's launching capital, supplemented by the insurance premium contributions, would allow even a 75% cost reimbursement to failed projects when assuming an 80% success rate. Only in exceptional cases, the fund assets would be used entirely before the end of the ten years (case: 4% premium; 75% risk coverage; 3 projects/year).

Thus, the initiation of such an RMS can be encouraging for both private and other investors (most likely, other than local governments), and for state bodies that would set up the fund, not only due to increasing the chances of developing more geothermal drilling projects but also due to the reduced involvement of public funds. At the same time, the initial public capital dedicated to the RMS would bring significant leverage effects assuming an 80% success rate: € 8 of investment for every public euro spent (30-project scenario), and € 5,33 of investment for every public €1 spent (20-project scenario).

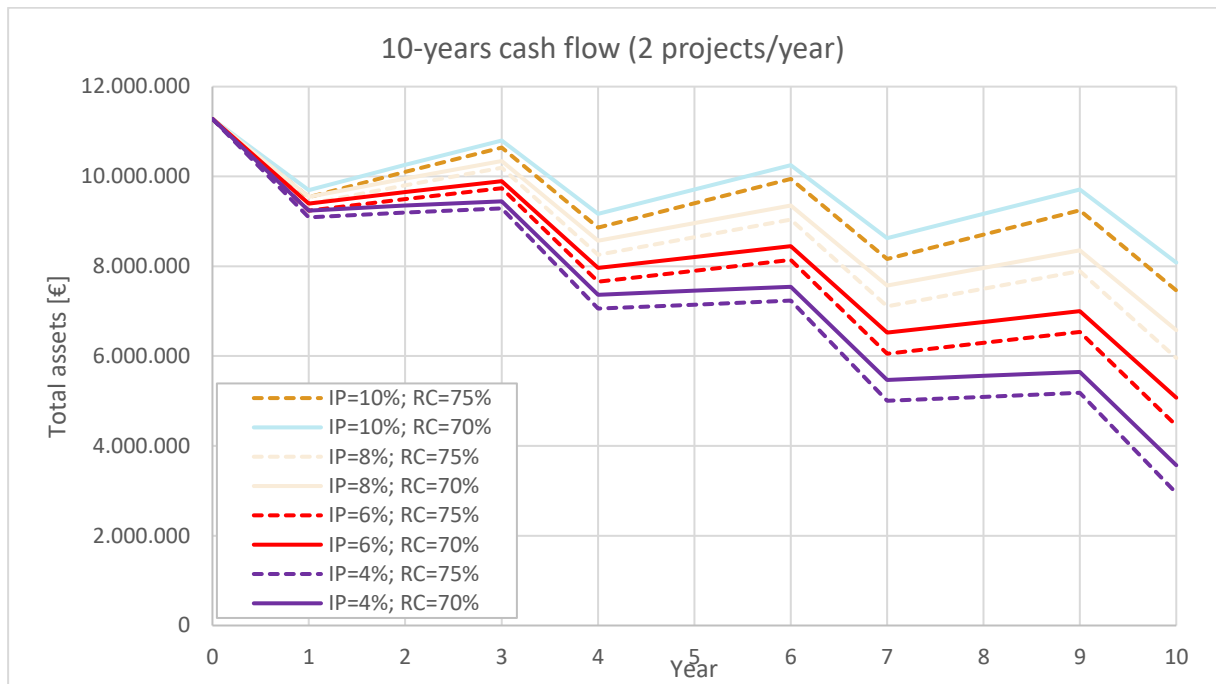


Figure 9. The Polish case: ten-year cash-flow of the proposed risk insurance fund for geothermal projects: 2 projects/year; 80% success rate; 20 projects in total (I.P. – insurance premium, R.C. – risk coverage).

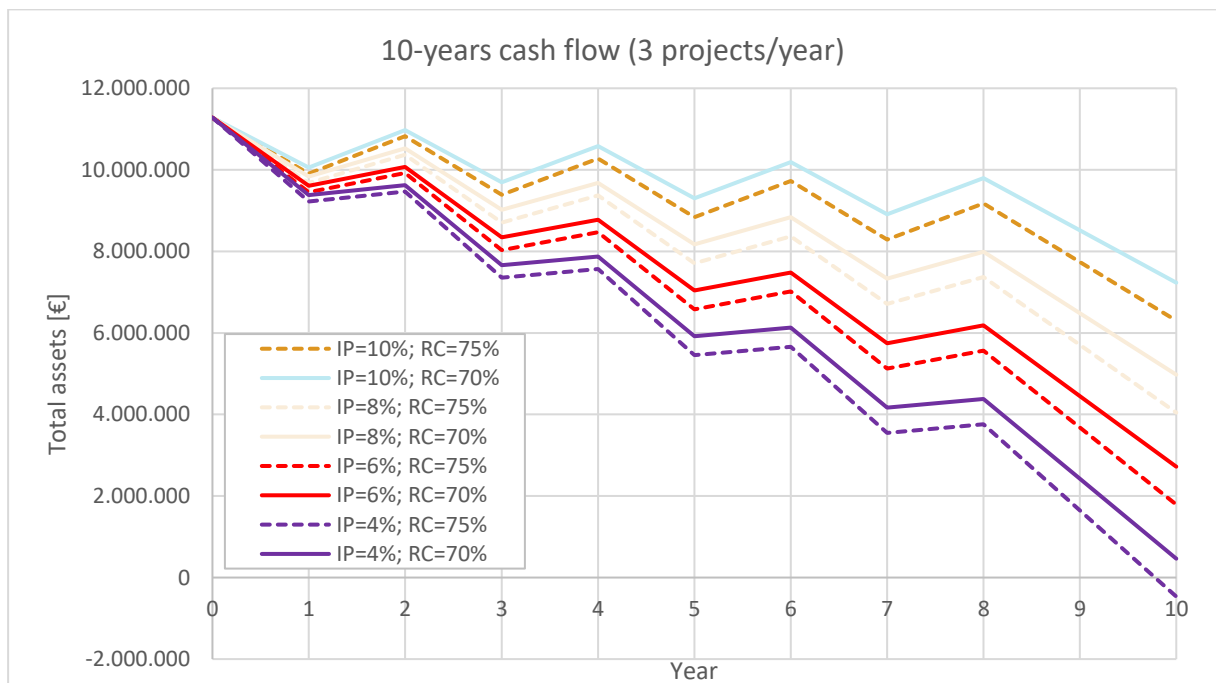


Figure 10. The Polish case: ten-year cash-flow of the proposed risk insurance fund for geothermal projects: 3 projects/year; 80% success rate; 30 projects in total (I.P. – insurance premium, R.C. – risk coverage).

5. Corrective measures

The Project partner teams from the three target countries have performed specific activities and actions within the GEORISK project towards the establishment of a national RMS in their countries. The general directions of these actions and activities were common, set by the Project. However, each country's team made the required adjustments to be in accordance with the particular national technical, legal, and financial characteristics, as presented above.

In any case, it should be mentioned that the establishment and launching of an RMS is a timely process, often affected by bureaucratic procedures, and either way, dependent on political will and availability of appropriate financial resources. Additionally, due to the COVID-19 (Corona Virus Disease 2019) pandemic, since early 2020 policymakers have exceptionally prioritized different topics in their agendas in some cases. However, through the GEORISK project, crucial steps towards the establishment of an RMS have been made in all three target countries compared to the “pre-GEORISK” situations.

As a first step, key stakeholders have been identified in the three countries (Task 4.1), including, among others, geothermal experts, private developers, insurance companies, financial institutions, national, regional, and local authorities' representatives. Contacts were made with them, and a first set of workshops was organized in each country (WP2) to present the initial findings of the GEORISK project and assess the potential geothermal projects' risks concerning each country. The workshops were conducted in March 2019 in Poland (Warsaw) and June 2019 in Greece (Athens) and Hungary (Budapest) [see D(2.5)].

Another crucial activity has been the conduction of a set of three national workshops per country within the works of Task 4.2. As mentioned above, the theme and timing of each workshop were modified according to national needs. However, in general, they included the presentation of GEORISK projects' results (mainly referring to the results of WP2 on risk assessment and WP3 on risk mitigation tools), the collection of stakeholders' opinions on the RMS requirements, and discussions on the development and establishment of an RMS (more information on the T4.2 national workshops will be available in D(4.3); available after June 2021). The opinions of the stakeholders were collected through two questionnaires which were distributed during specific workshops. The Hungarian partner GeoEX prepared and used the questionnaires first; as a next step, the questionnaires were also adopted by the Greek and Polish counterparts after translating them and modifying them based on their national specifications. The two questionnaires (English versions) are available in Annexes VI and VII, respectively.

One more central action towards the promotion of the establishment of an RMS has been the preparation and dispatch of open letters towards high-level decision-makers [D(4.2)]. The open letter, asking for the establishment of an insurance scheme mitigating geothermal risks, was prepared by EGEN and was translated and modified according to each countries' particularities. In Greece, the open letter was sent to 22 policy and decision-makers, targeting the Ministry of Environment and Energy; the Ministry of Development and Investments; the Ministry of Finance; Regional Administrations' Development Planning, Environment and Infrastructure Divisions. The Polish open letter was sent to the Minister of Environment, the Minister of Climate, the President of the National Fund for Environment Protection and Water Management; also, it was notified to the Secretary of State in the Ministry of Climate and the deputy President of NFEP&WM. As for Hungary, since the whole RMS-establishment process is more advanced than the other two target countries, there was no need to send the open letter since the communication with the high-level decision-makers was already well-founded.

Apart from the specifically-planned activities mentioned above, additional communication actions have been ongoing during the GEORISK project, always in the context of promoting the creation of an RMS. These activities include initial contacts with several stakeholders, regular communication with targeted individuals showing interest in the GEORISK project, and collaboration with key-persons within the context of the project's Advisory Committee (Task 1.3).

Based on the above activities, and in the context of the GEORISK project, specific progress has been made in each of the three target countries towards the promotion of the RMS establishment. Specifically:

- In Greece, currently, there is no geothermal RMS available. However, in the context of the GEORISK activities, the Ministry of Environment and Energy has shown interest in initiating such a scheme, preferably within the following year. In this context, an initial RMS proposal has been developed by CRES to be further elaborated in collaboration with the corresponding Ministry.
- Hungary is highly advanced in introducing a new RMS, probably within 2021. Besides, as it is the most progressed among the three target countries, Hungary creates a good example for Greece and Poland.
- Until now, an RMS has not been introduced in Poland. However, the main goal is to include the proper paragraphs and provisions on its establishment and the details of its operation into already existing legal and regulatory documents, e.g., into the Law of Environment Protection.

Additionally, it is worth highlighting the need to continue contacts and cooperation with the decision-makers to convince them on the necessity to act both on current support measures to enhance geothermal development (relevant for juvenile market) and, at the same time, to act towards the introduction of next measures like public risk insurance funds along with geothermal market development (what is expected in the coming years).

6. Conclusions

The establishment of RMS can help develop geothermal markets through increased investments by offering a tool that mitigates on a financial level potential geothermal projects' risks, with the most important one being the resource risk. However, such risk insurance funds have been launched in a limited number of European countries, such as France, Germany, Iceland, The Netherlands, Denmark, Switzerland, and Turkey. Three European countries with significant untapped geothermal potential that would benefit from the initiation of such schemes are Greece, Hungary, and Poland (GEORISK project's European target countries). In this context, this report aims to present the technical, legal, and financial aspects of the three countries' potential risk insurance schemes.

All three countries hold significant geothermal potential, either for heat or power generation, with each one presenting its particular geological characteristics and levels of geothermal exploration. Hungary, positioned above the Pannonian Basin, is already well-explored, and a sufficient amount of data has been collected through the existing 8.000 hydrocarbon and 1.000 geothermal wells and dense seismic lines and blocks. Thus, the assumption of a 90% project success rate is valid since only EGS projects carry a high risk. On the other hand, the particular geology of Greece has created more diverse geothermal conditions. High-temperature resources are located on the active Aegean volcanic arc, while low-temperature reservoirs can be found in other areas, mainly concentrated in northern Greece. However, there is limited exploration of the high-temperature resources. This means that although a project success rate of 90% can be assumed for explored fields (either high or low enthalpy), the potential success rate of insufficiently explored fields (i.e., the majority of the high-temperature ones) could be assumed to be around 67%, or even lower. As for Poland, it should be noted that the diverse geostructural elements have led to different geothermal conditions. Hence, the geothermal resources are mainly located in two of the five Polish geothermal units (namely, the Polish Lowlands and the Inner Carpathians), are of low-temperatures, and are located several hundred meters below the ground level (i.e., deep geothermal applications). In any case, based on the given conditions, the success rate of potential projects can be assumed to be, in general, approximately 80%.

Following on from the examination of the technical conditions, the legal basis for establishing an RMS was mapped for each country, having in mind that none of them have launched such a scheme until now. Thus, the legislations and policies that can become the foundation of such schemes were identified and presented. Among the three target countries, Hungary is the most

advanced in introducing an RMS, probably during 2021. This has already been well-grounded at a policy level through the new National Energy Strategy and the National Energy and Climate Plan, with both documents mentioning the Geothermal Guarantee Fund. By all means, the development of the Hungarian RMS has been established on a solid basis, with the Action Plan on the Utilization and Management of Energetic Mineral Resources setting the task of preparing a proposal for the mitigation of high upfront risks of geothermal projects by introducing financial tools, by June 2019. In Greece's case, the National Energy and Climate Plan (2019) includes a section on "Risk factors and challenges" for RES, acknowledging the importance of risk mitigation and proposing –in a general manner- the use of relevant tools. Apart from this plan, a mention could be made to Greek Law 4602/2019 which makes a general reference to incentives for geothermal energy development support. Thus, these two documents could be the core for introducing a geothermal-focused RMS in Greece. Likewise, legislative and policy documents that could put forward or reference a Polish geothermal RMS were identified. Such a document is the Environment Protection Law, which sets a legal basis for establishing geothermal public financial support. Additionally, the electricity-focused Act on Renewable Energy Sources could also play this role, as it verifies the State's involvement in supporting RES market uptake. On top of that, it is worth acknowledging the Polish Energy Law and Poland's Energy Policy until 2040, in the context of proposing the utilization of targeted RMS.

After having assessed the relevant technical and legal aspects, the next step was the evaluation of the financial sustainability of a presumed RMS in each country for ten years. To conduct the simulation, specific parameters were defined, including the number and nature of expected projects, the initial designated capital, the operational costs of the scheme, the level of insurance premium and risk coverage, and the expected success rate. In addition, targeted sensitivity analyses were performed, and alternative scenarios were evaluated to investigate each parameter's effect on the RMS financial sustainability. Specifically, all three countries investigated the effect of different levels of insurance premiums and risk coverages; additionally, Greece investigated the impact of different success rates and Poland the results that different numbers of implemented projects during the ten years would have. The results of the simulation, when taking into account specific insurance premium (10%) and risk coverage (75%), are the following for the three countries:

- The Hungarian RMS is financially sustainable and could continue its operation even after the ten years, as within this period it has lost only 4% (i.e., € 400.000) of its initial capital;

- Depending on the assumed success rate, the Greek RMS could take a range of different outcomes; from a "collapse" after six to eight years, up to financial sustainability exceeding the ten years;
- The Polish RMS is financially sustainable for the ten years, with the fund's capital depending on the amount of implemented projects within this period; however, the results show that after this period, it would probably require an "injection" of capital, as it would have lost around 25 to 40% of the initial capital.

As mentioned above, these estimations were made on a common basis of insurance premium and risk coverage. This means that the identified deviations between the three countries mainly result from the different levels of projects' success rates, which in their turn result from the different levels of geothermal exploration in each country, as already presented above. Indeed, the financial sustainability –even after the ten years- of the Hungarian RMS results from a 90% success rate, which corresponds to a high level of exploration and data availability. The mixed Greek results are following the country's exploration status: as most high-enthalpy fields are still unexplored, their success rate is assumed to range between 50 and 75%, while the exclusion of these projects from the simulation would lead to an overall 90% success rate. Poland's national geothermal conditions justify an 80% success rate, which –independent from the number of developed projects- would result in a financially sustainable RMS, at least for ten years.

Closing with the results of the performed simulation, it should be noted that the specific work presents the conditions under which sustainability is achieved or the necessity for further public support. As mentioned in the previous paragraph, the RMS sustainability's most sensitive factor is the success rate –concerning each country's geothermal conditions and exploration status, meaning that the successful operation of an RMS requires the highest possible success rate. In any case, the importance of the additional factors should not be overlooked.

A different issue related to the RMS simulation has to do with the estimated period and the type of risks covered. The specific analysis focuses on the short-term resource risk (i.e., not finding an economically sustainable geothermal resource after drilling) without examining the operation of a scheme covering the long-term resource risk (i.e., natural depletion of the geothermal resource). The specific risk has been identified as of high importance by the relevant stakeholders. Thus, future research could focus on the simulation of a long-term RMS, with its results being valuable for identifying the suitable RMS in each country.

Based on the above financial analysis and under the presented technical and legal aspects, it is evident that establishing an RMS in all target countries is both meaningful and feasible.

However, none of the three countries have yet launched an RMS, which, in any case, should be noted that it is a timely procedure, affected by bureaucratic procedures, political will, and availability of funds. This is why during the planning of a new RMS, it is crucial to consider the long experience of the former and existing schemes.

On these terms, several activities have been performed in this direction within the GEORISK project, including identifying key-stakeholders, communication of the project and its results, exchanging information, and collecting opinions and feedback, all in the context of promoting the geothermal RMS initiation. Accordingly, Hungary is highly advanced in introducing a new RMS, probably within 2021. Greece is in the process of developing an RMS proposal, as the Ministry of Environment and Energy has shown interest in initiating such a scheme. Poland's goal is to include the proper paragraphs and provisions into existing legal and regulatory documents, such as the Law of Environment Protection.

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ANNEX I

Ten years operating simulation of the planned Greek RMS; Success rate scenario: 90% high enthalpy explored / 67% high enthalpy unexplored / 90% low enthalpy explored

Year	No.	Project Identification and Type	Geological formation, identification of the aquifer	Contract Type, Duration	Available data (G&G studies, Project Concept)	Project capacity, MW, expected production,	Insured cost, €	Expected result and insurance decision
1	1	Milos production well	metamorphic basement	4 months	complete field picture	10 MWe	1.600.000	success
	2	Milos reinjection well	metamorphic basement	4 months	complete field picture	-	1.600.000	success
	3	1st Aristino production well	andesites	3 months	part of field explored	7 MWth	650.000	success
	4	2nd Aristino production well	andesites	3 months	part of field explored	7 MWth	650.000	success
	5	3rd Aristino production well	andesites	3 months	part of field explored	7 MWth	650.000	success
2	6	Nisyros production well	marble, limestone	4 months	part of field explored	5 MWe	1.900.000	success
	7	Nisyros reinjection well	marble, limestone	4 months	part of field explored	-	1.900.000	success
	8	1st Aristino reinjection well	andesites	3 months	part of field explored	-	650.000	success
	9	2nd Aristino reinjection well	andesites	3 months	part of field explored	-	650.000	success
	10	3rd Aristino reinjection well	andesites	3 months	part of field explored	-	650.000	success
3	11	Methana production well	crystalline basement	4 months	geophysics only	5 MWe	1.700.000	success
	12	Methana deep well	crystalline basement	4 months	geophysics only	-	1.700.000	failure, pay risk cover
	13	Methana reinjection well	crystalline basement	4 months	geophysics only	-	1.700.000	success
	14	1st Nea Kessani production well	base conglomerate	3 months	field explored	4 MWth	650.000	success
	15	2nd Nea Kessani production well	base conglomerate	3 months	field explored	4 MWth	650.000	success
	16	Low Enthalpy well	base conglomerate	3 months	field explored	-	650.000	failure, pay risk cover
	17	3rd Nea Kessani production well	base conglomerate	3 months	field explored	4 MWth	650.000	success
4	18	Lesvos production well	crystalline basement	6 months	geophysics only	8 MWe	3.700.000	success
	19	Lesvos deep well	crystalline basement	6 months	geophysics only	-	3.700.000	failure, pay risk cover
	20	1st Nea Kessani reinjection well	base conglomerate	3 months	field explored	-	650.000	success
	21	2nd Nea Kessani reinjection well	base conglomerate	3 months	field explored	-	650.000	success
	22	3rd Nea Kessani reinjection well	base conglomerate	3 months	field explored	-	650.000	success
5	23	Lesvos reinjection well	crystalline basement	6 months	geophysics only	-	3.700.000	success
	24	Soussaki production well	limestones	6 months	new area	5 MWe	3.100.000	success
	25	1st Nigrita production well	base conglomerate	3 months	part of field explored	4 MWth	650.000	success
	26	2nd Nigrita production well	base conglomerate	3 months	part of field explored	4 MWth	650.000	success
	27	Low Enthalpy well	base conglomerate	3 months	part of field explored	-	650.000	failure, pay risk cover
	28	3rd Nigrita production well	base conglomerate	3 months	part of field explored	4 MWth	650.000	success

CONTINUE: Ten years operating simulation of the planned Greek RMS; Success rate scenario: 90% high enthalpy explored / 67% high enthalpy unexplored / 90% low enthalpy explored

Year	No.	Project Identification and Type	Geological formation, identification of the aquifer	Contract Type, Duration	Available data (G&G studies, Project Concept)	Project capacity, MW, expected production,	Insured cost, €	Expected result and insurance decision
6	29	Soussaki deep well	limestones	6 months	new area	-	3.100.000	failure, pay risk cover
	30	Soussaki reinjection well	limestones	6 months	new area	-	3.100.000	success
	31	1st Nigrita reinjection well	base conglomerate	3 months	part of field explored	-	650.000	success
	32	2nd Nigrita reinjection well	base conglomerate	3 months	part of field explored	-	650.000	success
	33	3rd Nigrita reinjection well	base conglomerate	3 months	part of field explored	-	650.000	success
7	34	Samothraki production well	diabases	6 months	new area	5 MWe	3.700.000	success
	35	Samothraki deep well	diabases	6 months	new area	-	3.700.000	failure, pay risk cover
	36	1st Herakeia production well	base conglomerate	3 months	field explored	4 MWth	650.000	success
	37	2nd Herakeia production well	base conglomerate	3 months	field explored	4 MWth	650.000	success
	38	3rd Herakeia production well	base conglomerate	3 months	field explored	4 MWth	650.000	success
8	39	Samothraki reinjection well	diabases	6 months	new area	-	3.700.000	success
	40	Chios deep well	detrital formations	6 months	new area	-	3.700.000	failure, pay risk cover
	41	1st Herakeia reinjection well	base conglomerate	3 months	field explored	-	650.000	success
	42	2nd Herakeia reinjection well	base conglomerate	3 months	field explored	-	650.000	success
	43	3rd Herakeia reinjection well	base conglomerate	3 months	field explored	-	650.000	success
9	44	Chios production well	detrital formations	6 months	new area	5 MWe	3.700.000	success
	45	Chios reinjection well	detrital formations	6 months	new area	-	3.700.000	success
	46	Akropotamos production well	base conglomerate	3 months	part of field explored	7 MWth	650.000	success
	47	Akropotamos production well	base conglomerate	3 months	part of field explored	7 MWth	650.000	success
	48	Low Enthalpy well	base conglomerate	3 months	part of field explored	-	650.000	failure, pay risk cover
10	49	Akropotamos production well	base conglomerate	3 months	part of field explored	7 MWth	650.000	success
	50	Thera production well	crystalline basement	4 months	new area	5 MWe	2.500.000	success
	51	Thera deep well	crystalline basement	4 months	new area	-	2.500.000	failure, pay risk cover
	52	Thera reinjection well	crystalline basement	4 months	new area	-	2.500.000	success
	53	Akropotamos reinjection well	base conglomerate	3 months	part of field explored	-	650.000	success
	54	Akropotamos reinjection well	base conglomerate	3 months	part of field explored	-	650.000	success
	55	Akropotamos reinjection well	base conglomerate	3 months	part of field explored	-	650.000	success

ANNEX II

Ten years operating simulation of the planned Greek RMS: Sensitivity analysis between Risk Coverage and Insurance Premium																	
Success rate scenario: 90% high enthalpy explored / 67% high enthalpy unexplored / 90% low enthalpy explored																	
INSURANCE PREMIUM																	
		5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
RISK COVERAGE	5%	10.765.000	11.601.500	12.438.000	13.274.500	14.111.000	14.947.500	15.784.000	16.620.500	17.457.000	18.293.500	19.130.000	19.966.500	20.803.000	21.639.500	22.476.000	23.312.500
	10%	9.747.500	10.584.000	11.420.500	12.257.000	13.093.500	13.930.000	14.766.500	15.603.000	16.439.500	17.276.000	18.112.500	18.949.000	19.785.500	20.622.000	21.458.500	22.295.000
	15%	8.730.000	9.566.500	10.403.000	11.239.500	12.076.000	12.912.500	13.749.000	14.585.500	15.422.000	16.258.500	17.095.000	17.931.500	18.768.000	19.604.500	20.441.000	21.277.500
	20%	7.712.500	8.549.000	9.385.500	10.222.000	11.058.500	11.895.000	12.731.500	13.568.000	14.404.500	15.241.000	16.077.500	16.914.000	17.750.500	18.587.000	19.423.500	20.260.000
	25%	6.695.000	7.531.500	8.368.000	9.204.500	10.041.000	10.877.500	11.714.000	12.550.500	13.387.000	14.223.500	15.060.000	15.896.500	16.733.000	17.569.500	18.406.000	19.242.500
	30%	5.677.500	6.514.000	7.350.500	8.187.000	9.023.500	9.860.000	10.696.500	11.533.000	12.369.500	13.206.000	14.042.500	14.879.000	15.715.500	16.552.000	17.388.500	18.225.000
	35%	4.660.000	5.496.500	6.333.000	7.169.500	8.006.000	8.842.500	9.679.000	10.515.500	11.352.000	12.188.500	13.025.000	13.861.500	14.698.000	15.534.500	16.371.000	17.207.500
	40%	3.642.500	4.479.000	5.315.500	6.152.000	6.988.500	7.825.000	8.661.500	9.498.000	10.334.500	11.171.000	12.007.500	12.844.000	13.680.500	14.517.000	15.353.500	16.190.000
	45%	2.625.000	3.461.500	4.298.000	5.134.500	5.971.000	6.807.500	7.644.000	8.480.500	9.317.000	10.153.500	10.990.000	11.826.500	12.663.000	13.499.500	14.336.000	15.172.500
	50%	1.607.500	2.444.000	3.280.500	4.117.000	4.953.500	5.790.000	6.626.500	7.463.000	8.299.500	9.136.000	9.972.500	10.809.000	11.645.500	12.482.000	13.318.500	14.155.000
	55%	590.000	1.426.500	2.263.000	3.099.500	3.936.000	4.772.500	5.609.000	6.445.500	7.282.000	8.118.500	8.955.000	9.791.500	10.628.000	11.464.500	12.301.000	13.137.500
	60%	-427.500	409.000	1.245.500	2.082.000	2.918.500	3.755.000	4.591.500	5.428.000	6.264.500	7.101.000	7.937.500	8.774.000	9.610.500	10.447.000	11.283.500	12.120.000
	65%	-1.445.000	-608.500	228.000	1.064.500	1.901.000	2.737.500	3.574.000	4.410.500	5.247.000	6.083.500	6.920.000	7.756.500	8.593.000	9.429.500	10.266.000	11.102.500
	70%	-2.462.500	-1.626.000	-789.500	47.000	883.500	1.720.000	2.556.500	3.393.000	4.229.500	5.066.000	5.902.500	6.739.000	7.575.500	8.412.000	9.248.500	10.085.000
	75%	-3.480.000	-2.643.500	-1.807.000	-970.500	-134.000	702.500	1.539.000	2.375.500	3.212.000	4.048.500	4.885.000	5.721.500	6.558.000	7.394.500	8.231.000	9.067.500
	80%	-4.497.500	-3.661.000	-2.824.500	-1.988.000	-1.151.500	-315.000	521.500	1.358.000	2.194.500	3.031.000	3.867.500	4.704.000	5.540.500	6.377.000	7.213.500	8.050.000
	85%	-5.515.000	-4.678.500	-3.842.000	-3.005.500	-2.169.000	-1.332.500	-496.000	340.500	1.177.000	2.013.500	2.850.000	3.686.500	4.523.000	5.359.500	6.196.000	7.032.500
90%	-6.532.500	-5.696.000	-4.859.500	-4.023.000	-3.186.500	-2.350.000	-1.513.500	-677.000	159.500	996.000	1.832.500	2.669.000	3.505.500	4.342.000	5.178.500	6.015.000	
95%	-7.550.000	-6.713.500	-5.877.000	-5.040.500	-4.204.000	-3.367.500	-2.531.000	-1.694.500	-858.000	-21.500	815.000	1.651.500	2.488.000	3.324.500	4.161.000	4.997.500	
100%	-8.567.500	-7.731.000	-6.894.500	-6.058.000	-5.221.500	-4.385.000	-3.548.500	-2.712.000	-1.875.500	-1.039.000	-202.500	634.000	1.470.500	2.307.000	3.143.500	3.980.000	

ANNEX III

Ten years operating simulation of the planned Hungarian RMS

No.	Project Identification	Geological formation, identification of the aquifer	Contract Type, Duration	Available data	Project capacity, MW, expected production, MWh/year	Insured cost, €	Expected result and insurance decision
1	pt 1.1. NW Transdanubia	porous	exploration, 2 years	G&G studies and Project concept	1,6 MW _{th} , 2400 MWh/y heat	2.500.000	successful
2	pt 3.1. SW Transdanubia	porous	exploration, 2 years	G&G studies and Project concept	4 wells, 0,8 MWth, 1200 MWh/y	800.000	successful
3	pt 2.1. S-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	3,2 MWth, 4800 MWh/y heat	3.000.000	successful
4	Basement South Great Plain	cristalline basement	hydrofracking, 2 years	G&G studies and Project concept	15 MWth, 5 MWe, 20000 MWh/y heat, 40000 MWh/y electricity	6.200.000	successful
5	kt 1.2.N-Transdanubia	karstic fractured	exploration, 2 years	G&G studies and Project concept	16 MWth, 24000 MWh/y heat	4.000.000	failure, pay risk cover
6	pt 2.2. N-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	4 wells, 2,4 MWth , 3600 MWh/y heat	1.600.000	successful
7	kt 1.9 South Transdanubia	karstic fractured	exploration, 2 years	G&G studies and Project concept	2 MWth, 3000 MWh/y heat	3.100.000	successful
8	pt 1.2. W-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	4 wells, 2,8 MWth, 4200 MWh/y heat	1.800.000	successful
9	Kt 1.11. Bük	karstic fractured	exploration, 2 years	G&G studies and Project concept	1,6 MWth, 2400 MWh/y heat	2.200.000	successful
10	kt 3.1 South Transdanubia	karstic fractured	exploration, 2 years	G&G studies and Project concept	6 MWth, 9000 MWh/y heat	5.500.000	successful
11	pt 1.2. W-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	0,7 MWth, 1100 MWh/y heat	1.000.000	successful
12	pt 2.4. NE-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	4 wells, 4 MWth, 6000 MWh/y heat	2.800.000	successful
13	pt 1.1. NW Transdanubia	porous	exploration, 2 years	G&G studies and Project concept	2,4 MWth, 3000 MWh/y heat	2.500.000	failure, pay risk cover
14	pt 2.3. SE-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	1 MWth, 1500 MWh/y heat	900.000	successful
15	kt 1.7 Mid Transdanubia	karstic fractured	exploration, 2 years	G&G studies and Project concept	1,2 MWth, 1800 MWh/y heat	2.000.000	successful
16	Basement South Great Plain	cristalline basement	hydrofracking, 2 years	G&G studies and Project concept	16 MW _{th} , 6 MWe, 24000 MWh/y heat, 48000 MWh/y electricity	9.000.000	successful
17	kt 1.6 Szabadbattyán thermal karst	karstic fractured	exploration, 2 years	G&G studies and Project concept	2 MWth, 3000 MWh/y heat	2.500.000	successful
18	pt 2.5. Intra-montane basin, North M.	porous	exploration, 2 years	G&G studies and Project concept	0,6 MWth, 1000 MWh/y heat	1.100.000	successful
19	kt 1.5 Northern Hungary	karstic fractured	exploration, 2 years	G&G studies and Project concept	5,2 MWth, 8000 MWh/y heat	3.700.000	successful
20	kt 2.3 Northern Hungary	karstic fractured	exploration, 2 years	G&G studies and Project concept	1,5 MWth, 2300 MWh/y heat	4.700.000	successful
21	pt 3.1. SW Transdanubia	porous	exploration, 2 years	G&G studies and Project concept	4 wells, 1,5 MWth, 2300 MWh/y heat	1.900.000	successful
22	kt 2.1 Northern Hungary	karstic fractured	exploration, 2 years	G&G studies and Project concept	9 MWth, 13500 MWh/y heat	5.000.000	successful
23	kt 1.8 Mecsek	karstic fractured	exploration, 2 years	G&G studies and Project concept	2 MWth, 3000 MWh/y heat	2.800.000	failure, pay risk cover
24	kt 1.3. Budapest	karstic fractured	exploration, 2 years	G&G studies and Project concept	4 wells, 4,4 MWth, 6600 MWh/y heat	3.100.000	successful
25	pt 2.2. N-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	4 wells, 2 MWth, 3000 MWh/y heat	2.000.000	successful
26	pt 2.4. NE-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	4 wells, 1,5 MWth, 2300 MWh/y heat	1.600.000	successful
27	kt 4.1 West Transdanubia	karstic fractured	exploration, 2 years	G&G studies and Project concept	2,5 MWth, 3800 MWh/y heat	5.800.000	successful
28	pt 2.3. SE-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	1,5 MWth, 2300 MWh/y heat	1.300.000	successful
29	Basement South Great Plain	cristalline basement	hydrofracking, 2 years	G&G studies and Project concept	14 MW _{th} , 5 MWe, 20000 MWh/y heat, 40000 MWh/y electricity	6.100.000	successful
30	pt 2.1. S-ern part of the Great Plain	porous	exploration, 2 years	G&G studies and Project concept	4,5 MWth, 6800 MWh/y heat	2.500.000	successful

ANNEX IV

Poland – geothermal drilling projects: ongoing, in various stages as in 2020 (based on deep geothermal projects registry – done as part of T4.2 realization).

Information of drillings and costs based on published information; costs resulted from tender procedures; catalogue of max unit costs applicable for projects funded from public support by NFEP&WM; own estimation. Wells drilled in 2016-beg. 2020; some drilled in earlier years, investments based on these well in various stages of realization in 2018 - 2020

Information type	Project 1	Project 2	Project 3	Project 4	Project 5	Project 6
Country - POLAND	Poland	Poland	Poland	Poland	Poland	Poland
Region	Masovian	Greater Poland	Greater Poland	Łódź	Masovian	West Pomeranian
Field	Polish Lowlands	Polish Lowlands	Polish Lowlands	Polish Lowlands	Polish Lowlands	Polish Lowlands
Project name	Jachranka	Koło	Konin	Sieradz	Sochaczew	Stargard
Geology type	Sedimentary - Sandstones	Sedimentary - Sandstones	Sedimentary - Sandstones	Sedimentary - Sandstones	Sedimentary - Sandstones	Sedimentary - Sandstones
Application: electricity/ thermal/ both	Thermal	Both	Both	Thermal	Thermal	Thermal
Application thermal or both; define thermal use	space heating, cooling, recreation	geoDH	space heating	geoDH	geoDH	geoDH
Number of production wells	1	1	1	1	1	2
Number of reinjection wells	1 planned	1 planned	1 planned	1 planned	1 planned	2
Max depth of production wells (m)	1772 m TVD	3905	2660	1505	1540	TVD 2700
Max depth of reinjection wells (m)	1756	similar as above	similar as above	similar as above	similar as above	TVD 2600
Max well-head temperature (°C)	44	86	95	52	44-47	85
Planned installed thermal capacity (MW _{th}), tent.	several M<W	ca. 10	ca. 10-15	several - 10?	several - 10	18
Planned installed electric capacity (MW _e)		?				
Planned production of electric energy (MWh/yr)		?	?			
Planned production of thermal energy (MWh/yr)	?	?	?	?	?	?
Flow rate (m ³ /h)	201	260	114	250	190	600 (300/1 well)
Planned time length of construction	ass. 2-3 yrs	3-5 yrs	?	ass. 2-3 yrs	ass. 2-3 yrs	ass. 2 yrs
<u>Drilling costs (PLN)</u>	ass. 15 mio PLN one well drilling costs	Well drilling costs ca. 23.7 mio PLN	Well drilling costs ca. 15.2 mio PLN	Well drilling costs ca. 10.9 mio PLN	Well drilling costs ca. 11.1 mio PLN	4 wells' drilling costs ca. 84 mio PLN
Private/ public/ both investment (define)	Private	Public	Public	Public	Public	Both
Grant/subsidy/other scheme (define)	Other scheme	Public grant eligible costs	50% public grant, 50% municipal DH company	Public grant eligible costs	Public grant eligible costs	50% public loan, 50% by operator
Insurance scheme	No	No	No	No	No	No
Expected lifespan of plant operation (yrs)	20-30?	20-30?	20-30?	20-30?	20-30?	20-30?
Additional remarks (1)	Public loans and grants possible for further investment stages					
Additional remarks (2)	Information of drillings and costs based on: published information; costs resulted from tender procedures; catalogue of max unit costs applicable for projects funded from public support by NFEP&WM; own estimation. Wells drilled in 2016-beg. 2020; some drilled in earlier yrs, investments based on these well in various stages of realization in 2018 - 2020					

Information type	Project 7	Project 8	Project 9	Project 10	Project 11
Country - POLAND	Poland	Poland	Poland	Poland	Poland
Region	Łódź	Greater Poland	Masovian	Subcarpathian	Lower Silesian
Field	Polish Lowlands	Polish Lowlands	Polish Lowlands	Carpathian Foredeep	Sudetes Region
Project name	Tomaszów Mazowiecki	Turek	Wręcza	Dębica	Łądek-Zdrój
Geology type	Sedimentary - Sandstones	Sedimentary - Sandstones	Sedimentary - Sandstones	Sedimentary - Carbonates	Metamorphic
Application: electricity/ thermal/ both	Thermal	Thermal	Thermal	Thermal	Thermal
Application thermal or both; define thermal use	heating, balneotherapy, recreation	geoDH	heat and water supply for huge recreation centre	geoDH	space heating, other
Number of production wells	1	1	1	1	1
Number of reinjection wells	tbc	1	?	?	?
Max depth of production wells (m)	2100	2100-2150	1688	3400	2500
Max depth of reinjection wells (m)		2100-2150		?	
Max well-head temperature (°C)	40	78	40	65-70	~45
Planned installed thermal capacity (MW _{th}), tent.	several - 10?	10 - 15?	tbc	tbc	tbc
Planned installed electric capacity (MW _e)					
Planned production of electric energy (MWh/yr)					
Planned production of thermal energy (MWh/yr)	?	?	?	?	?
Flow rate (m ³ /h)		200	150	>70	60
Planned time length of construction	2-3 yrs	2-3 yrs	2-3 yrs	tbc	3-5 yrs
<u>Drilling costs (PLN)</u>	Well drilling costs ca. 11.7 mio PLN	Well drilling costs ca.14.4 mio PLN (1 well), 16.1 for planned injection well	Well drilling costs ca. 11.8 mio PLN	Well drilling costs ca. 21.2 mio PLN	Well drilling costs ca. 15.4 mio PLN
Private/ public/ both investment (define)	Public	Public	Private	Public	Public
Grant/subsidy/other scheme (define)	Public grant eligible costs	Public grant eligible costs		Public grant eligible costs	Public grant eligible costs
Insurance scheme	No	No	No		No
Expected lifespan of plant operation (yrs)	20-30?	20-30?	20-30?		
Additional remarks (1)	Public loans and grants possible for further investment stages			Public loans and grants possible for further investment stages	
Additional remarks (2)	Information of drillings and costs based on: published information; costs resulted from tender procedures; catalogue of max unit costs applicable for projects funded from public support by NFEP&WM; own estimation. Wells drilled in 2016-beg. 2020; some drilled in earlier yrs, investments based on these well in various stages of realization in 2018 - 2020				

Poland – geothermal drilling projects under investigation, planned as in 2020 (based on deep geothermal projects registry – done as part of T4.2 realization).

Based on: published information; catalogue of max unit costs applicable for projects funded from public support by NFEP&WM; own estimation. Some drilling projects possible to be conducted provided that public support would be granted (not in several cases).

Information type	Projects 1-34	Project 35	Project 36	Project 37	Project 38
Country	Poland	Poland	Poland	Poland	Poland
Region	Several different voivodeships (NUTS-2 level)	Lesser Poland			
Field	Polish Lowlands	Inner Carpathians (Podhale Region)			Outer Carpathians
Project name	For ca. 34 localities - deep projects proposals based on ave. 2-3 km's deep wells (Cr3 - J3).	Banska PGP-4 (field Podhale-1)	Biały Dunajec PGP-5 (field Podhale 1)	Szymoszkowa GT-2 (field Szymoszkowa 1)	Sękowa
Project stage completed (e.g. geophysical survey, drilling exploration)	Research / production well's drilling projects elaborated, applications for public funding (grants, loans) from 2016-19 programs rejected (formal reasons; but part of applications will be submitted again provided the criteria are extended or other programs introduced). Some projects expected to be conducted thanks to loans or other sources (number of wells etc. acc. to published data (Dziadzio et al., 2020), Ministry of Climate, other sources).	Seismic survey done. Public grant donated. Start of drilling research-production well expected in 2020	Seismic survey done for part of fields in beg. 2000s. Drilling project elaborated. Application for public grant rejected so far. New attempts to be made.	Drilling project elaborated. Application for public grant rejected (2018/19)	Drilling project elaborated. Public grant donated
Geology type (define)	Sedimentary - Sandstones	Sedimentary - Carbonates/Sandstones	Sedimentary - carbonates	Sedimentary - carbonates, sandstones	Sedimentary - Sandstones
Application: electricity/ thermal/ both (define)	Thermal	Both	Thermal	Thermal	Thermal
IF application thermal or both; define thermal use/s	geoDH mostly. Some other uses in addition: CHP, recreation, greenhousing, etc.	geoDH, other, some electricity	geoDH	space heating, recreation	space heating, other
Number of production wells	ca. 30 research - production wells	1		1	1
Number of reinjection wells	at least 4 injection wells planned. More injection wells will follow when research/production wells will be drilled		1		
Max depth of production wells (m)	<i>typically 2-3 km, some deeper</i>	5300 (aquifers expected at 2.5-3.5, 4.2-4.8 km)	MD 3524 / TVD3200	ca. 2000 m	3000

Information type	Projects 1-34	Project 35	Project 36	Project 37	Project 38
Max depth of reinjection wells (m)	as above (if planned in the future)				
Max well-head temperature (°C)		90 - 120	ca. 80	35-40	ca. 60
Planned installed thermal capacity (MW _{th}), tentative	several - 10 - 15	18		several	Negative well
Planned installed electric capacity (MW _e) - not available / na					
Planned production of electric energy (MWh/ yr) not available / na					
Planned production of thermal energy (MWh/ yr) not available / na					6 1/2
Flow rate (m ³ /h, L/s or kg/s)	appr. 50 - 300 m ³ /h (will be known when well is drilled and tested)	ass. > 100			40-70
Planned time length of construction (yrs)	2-5 yrs	ca. 4 yrs	1 yrs (well only) Drilling the well expected in 2020-21	1-2 yrs (Drilling the well expected in 2020-21)	1- 3 yrs (Drilling the well expected in 2020-21)
Total investment costs (drilling costs only) (PLN / €)	ass. 510 mio PLN total	Well drilling costs ca. 47.2 mio PLN	Well drilling costs ca. 22 mio PLN	Ca. 15 mio PLN drilling costs	Well drilling costs ca. 17.7 mio PLN
Private/ public/ both investment (define)		Public	Both	Private	Public
Grant/ subsidy/ other scheme (define)	Grants/ subsidies/ loans/other schemes (expected prevailing share of public grants, loan and other subsidies)	Public grant > 90%, some input by the county	Efforts to obtain public support in progress	Exact scheme not known	Public grant > 90%, some input by municipality
Insurance scheme		No	No	No	No
Expected lifespan of plant operation (yrs)	20-30?	20-30?	20-30?	20-30?	20-30?
Additional remarks (1)	Public loans and grants are possible for further investment stages in some cases				Public loans and grants are possible for further investment stages in some cases

Information type	Project 39	Projects 40-43	Projects 44-47	Projects 48-52	Projects 53-60
Country	Poland	Poland	Poland	Poland	Poland
Region	Subcarpathian	Different voivodeships in southern Poland		Lower Silesian	Several different voivodeships (NUTS-2)
Field	Outer Carpathians	Outer Carpathians	Carpathian Foredeep	Sudetes Region	Various fields
Project name	Wiśniowa	At least for further 3 localities deep projects proposals based on ave. 2-3 km's deep wells	At least for 4 localities deep projects proposals based on ave. 2-3 km's deep wells	At least for 5 localities deep projects proposals based on ave. 2-3 km's wells.	Several more wells / projects
Project stage completed (e.g. geophysical survey, drilling exploration)	Drilling project elaborated. Public grant donated	Drilling projects elaborated (research / production wells), applications for public funding (grants, loans) from 2016-19 programs rejected (formal reasons; but part of applications will be submitted again provided the criteria are extended or other programs introduced). Some projects expected to be conducted thanks to loans or other sources (number of wells etc. acc. to published data (Dziadzio et al., 2020), Ministry of Climate, other sources).	Drilling projects elaborated (research / production wells), applications for public funding (grants, loans) from 2016-19 programs rejected (formal reasons; but part of applications will be submitted again provided the criteria are extended or other programs introduced). Some projects expected to be conducted thanks to loans or other sources (number of wells etc. acc. to published data (Dziadzio et al., 2020), Ministry of Climate, other sources).	Drilling projects elaborated (research / production wells), applications for public funding (grants, loans) from 2016-19 programs rejected (formal reasons; but part of applications will be submitted again provided the criteria are extended or other programs introduced). Some projects expected to be conducted thanks to loans or other sources (number of wells etc. acc. to published data (Dziadzio et al., 2020), Ministry of Climate, other sources).	Drilling projects elaborated, some oriented for heating, have not applied for public funding so far, low investment probabilities as in 2020
Geology type (define)	Sedimentary - Sandstones	Sedimentary	Sedimentary	Crystalline, metamorphic, Palaeozoic, Precambrian	Sedimentary, crystalline, metamorphic
Application: electricity/ thermal/ both (define)	Thermal				Thermal, recreation, other
IF application thermal or both; define thermal use/s	space heating, other	space heating (geoDH?), recreation, other	space heating (geoDH?), recreation, other		
Number of production wells	1	3 research - production wells	4 research - production wells	5 research - production wells	research / production
Number of reinjection wells					
Max depth of production wells (m)	?	typically 2-3 km, some deeper	typically 2-3 km, some deeper	typically 2-3 km, some deeper	
Max depth of reinjection wells (m)		as above			
Max well-head temperature (°C)	?	ass. 50-80	ass. 50-80	ass. 70-90	ca. 40-80
Planned installed thermal capacity (MW _{th}), tentative	?	several - 10	several - 10	several - 10 - 15	?
Planned installed electric capacity (MW _e) - not available / na					

Information type	Project 39	Projects 40-43	Projects 44-47	Projects 48-52	Projects 53-60
Planned production of electric energy (MWh/ yr) not available / na					
Planned production of thermal energy (MWh/ yr) not available / na					
Flow rate (m ³ /h, L/s or kg/s)	? 150	appr. 50 - 100 m ³ /h, more? (will be known when well will be drilled and tested)	appr. 50 - 100 m ³ /h, more? (will be known when well will be drilled and tested)	appr. 50 - 100 m ³ /h, more? (will be known when well will be drilled and tested)	will be known when well will be drilled and tested
Planned time length of construction (yrs)	1-3 yrs (Drilling the well expected in 2020-21)	1-3 yrs (Drilling the well expected in 2020-21)			
Total investment costs (drilling costs only) (PLN / €)	Well drilling and other costs ca. 40 mio PLN	ass. 45 mio PLN (15 mio PLN /well)	ass. 60 mio PLN (15 mio PLN /well)	ass. 75 mio PLN (15 mio PLN /well)	ass. 100 PLN (15 mio PLN /well)
Private/ public/ both investment (define)					
Grant/ subsidy/ other scheme (define)	Public grant > 90%, some input by municipality	Applications for public funding by 2016-2019 programs rejected. Further efforts to obtain public funds in progress	Applications for public funding by 2016-2019 programs rejected. Further efforts to obtain public funds in progress	Applications for public funding by 2016-2019 programs rejected. Further efforts to obtain public funds in progress	
Insurance scheme	No	No	No	No	No
Expected lifespan of plant operation (yrs)	20-30?	20-30?	20-30?	20-30?	
Additional remarks (1)	Public loans and grants are possible for further investment stages in some cases				

ANNEX V

Description of the 10 years operation, 2 projects/year									
Year	Operations	Number of newly contracted Projects	List of pending Projects	List of closed Projects	Number of unsuccessful projects	Income, €	Expenses, €	Payment for unsuccessful projects, €	Total Asset Balance €
1	All drillings are equal in terms of depth and cost. They have been averaged based on over 50 geothermal projects under development or under investigation in Poland. Average depth of geothermal well: 2606 m Average net cost: 3,76 M€	2	2	0	1	11 581 590	170 000	2 325 000	9 086 590
2		2	4	0	0	300 821	190 000	0	9 197 410
3		2	6	2	0	300 821	210 000	0	9 288 231
4		2	6	2	1	300 821	210 000	2 325 000	7 054 051
5		2	6	2	0	300 821	210 000	0	7 144 872
6		2	6	2	0	300 821	210 000	0	7 235 692
7		2	6	2	1	300 821	210 000	2 325 000	5 001 513
8		2	6	2	0	300 821	210 000	0	5 092 333
9		2	6	2	0	300 821	210 000	0	5 183 154
10		2	6	2	1	300 821	210 000	2 325 000	2 948 974

Success rate: 80%

Description of the 10 years operation, 3 projects/year									
Year	Operations	Number of newly contracted Projects	List of pending Projects	List of closed Projects	Number of unsuccessful projects	Income, €	Expenses, €	Payment for unsuccessful projects, €	Total Asset Balance €
1	All drillings are equal in terms of depth and cost. They have been averaged based on over 50 geothermal projects under development or under investigation in Poland. Average depth of geothermal well: 2606 m Average net cost: 3,76 M€	3	3	0	1	11 732 000	180 000	2 325 000	9 227 000
2		3	6	0	0	451 231	210 000	0	9 468 231
3		3	9	3	1	451 231	240 000	2 325 000	7 354 462
4		3	9	3	0	451 231	240 000	0	7 565 692
5		3	9	3	1	451 231	240 000	2 325 000	5 451 923
6		3	9	3	0	451 231	240 000	0	5 663 154
7		3	9	3	1	451 231	240 000	2 325 000	3 549 385
8		3	9	3	0	451 231	240 000	0	3 760 615
9		3	9	3	1	451 231	240 000	2 325 000	1 646 846
10		3	9	3	1	451 231	240 000	2 325 000	-466 923

Success rate: 80%

Results of the 10-years simulation, for 2 and 3 geothermal drillings annually

Number of projects/year	Estimated Success Rate	Successful / Unsuccessful	Insurance premium	Risk cover	Total assets at the end of year, €					
					0	1	2	3	4	5
3	80%	24/6	10%	70%	€ 11 280 769	€ 10 058 846	€ 10 976 923	€ 9 695 000	€ 10 583 077	€ 9 301 154
3	80%	24/6	8%	70%	€ 11 280 769	€ 9 833 231	€ 10 525 692	€ 9 018 154	€ 9 680 615	€ 8 173 077
3	80%	24/6	6%	70%	€ 11 280 769	€ 9 607 615	€ 10 074 462	€ 8 341 308	€ 8 778 154	€ 7 045 000
3	80%	24/6	4%	70%	€ 11 280 769	€ 9 382 000	€ 9 623 231	€ 7 664 462	€ 7 875 692	€ 5 916 923
3	80%	24/6	10%	75%	€ 11 280 769	€ 9 903 846	€ 10 821 923	€ 9 385 000	€ 10 273 077	€ 8 836 154
3	80%	24/6	8%	75%	€ 11 280 769	€ 9 678 231	€ 10 370 692	€ 8 708 154	€ 9 370 615	€ 7 708 077
3	80%	24/6	6%	75%	€ 11 280 769	€ 9 452 615	€ 9 919 462	€ 8 031 308	€ 8 468 154	€ 6 580 000
3	80%	24/6	4%	75%	€ 11 280 769	€ 9 227 000	€ 9 468 231	€ 7 354 462	€ 7 565 692	€ 5 451 923
2	80%	16/4	10%	70%	€ 11 280 769	€ 9 692 821	€ 10 254 872	€ 10 796 923	€ 9 168 974	€ 9 711 026
2	80%	16/4	8%	70%	€ 11 280 769	€ 9 542 410	€ 9 954 051	€ 10 345 692	€ 8 567 333	€ 8 958 974
2	80%	16/4	6%	70%	€ 11 280 769	€ 9 392 000	€ 9 653 231	€ 9 894 462	€ 7 965 692	€ 8 206 923
2	80%	16/4	4%	70%	€ 11 280 769	€ 9 241 590	€ 9 352 410	€ 9 443 231	€ 7 364 051	€ 7 454 872
2	80%	16/4	10%	75%	€ 11 280 769	€ 9 537 821	€ 10 099 872	€ 10 641 923	€ 8 858 974	€ 9 401 026
2	80%	16/4	8%	75%	€ 11 280 769	€ 9 387 410	€ 9 799 051	€ 10 190 692	€ 8 257 333	€ 8 648 974
2	80%	16/4	6%	75%	€ 11 280 769	€ 9 237 000	€ 9 498 231	€ 9 739 462	€ 7 655 692	€ 7 896 923
2	80%	16/4	4%	75%	€ 11 280 769	€ 9 086 590	€ 9 197 410	€ 9 288 231	€ 7 054 051	€ 7 144 872

Results of the 10-years simulation, for 2 and 3 geothermal drillings annually (continuation)

Number of projects/year	Estimated Success Rate	Successful / Unsuccessful	Insurance premium	Risk cover	Total assets at the end of year, €				
					6	7	8	9	10
3	80%	24/6	10%	70%	€ 11 280 769	€ 10 058 846	€ 10 976 923	€ 9 695 000	€ 10 583 077
3	80%	24/6	8%	70%	€ 11 280 769	€ 9 833 231	€ 10 525 692	€ 9 018 154	€ 9 680 615
3	80%	24/6	6%	70%	€ 11 280 769	€ 9 607 615	€ 10 074 462	€ 8 341 308	€ 8 778 154
3	80%	24/6	4%	70%	€ 11 280 769	€ 9 382 000	€ 9 623 231	€ 7 664 462	€ 7 875 692
3	80%	24/6	10%	75%	€ 11 280 769	€ 9 903 846	€ 10 821 923	€ 9 385 000	€ 10 273 077
3	80%	24/6	8%	75%	€ 11 280 769	€ 9 678 231	€ 10 370 692	€ 8 708 154	€ 9 370 615
3	80%	24/6	6%	75%	€ 11 280 769	€ 9 452 615	€ 9 919 462	€ 8 031 308	€ 8 468 154
3	80%	24/6	4%	75%	€ 11 280 769	€ 9 227 000	€ 9 468 231	€ 7 354 462	€ 7 565 692
2	80%	16/4	10%	70%	€ 11 280 769	€ 9 692 821	€ 10 254 872	€ 10 796 923	€ 9 168 974
2	80%	16/4	8%	70%	€ 11 280 769	€ 9 542 410	€ 9 954 051	€ 10 345 692	€ 8 567 333
2	80%	16/4	6%	70%	€ 11 280 769	€ 9 392 000	€ 9 653 231	€ 9 894 462	€ 7 965 692
2	80%	16/4	4%	70%	€ 11 280 769	€ 9 241 590	€ 9 352 410	€ 9 443 231	€ 7 364 051
2	80%	16/4	10%	75%	€ 11 280 769	€ 9 537 821	€ 10 099 872	€ 10 641 923	€ 8 858 974
2	80%	16/4	8%	75%	€ 11 280 769	€ 9 387 410	€ 9 799 051	€ 10 190 692	€ 8 257 333
2	80%	16/4	6%	75%	€ 11 280 769	€ 9 237 000	€ 9 498 231	€ 9 739 462	€ 7 655 692
2	80%	16/4	4%	75%	€ 11 280 769	€ 9 086 590	€ 9 197 410	€ 9 288 231	€ 7 054 051

ANNEX VI

GeoRisk Project, WP4: Questionnaire on the premises of the Hungarian Geothermal Risk Insurance Scheme, to be discussed in the National Workshop

No.	Title	Options	Remark on other issues
1.	Scheme sponsor	<ul style="list-style-type: none"> a) State only b) State and when sustainable to be privatized c) Private d) Public and private partnership e) International finance sources f) Other 	
2.	Geographical scope	<ul style="list-style-type: none"> a) Hungary b) Hungary, neighbour countries can join (all countries finance their costs) c) Pannonian Basin d) European Geothermal Risk Insurance Scheme e) International without country preference f) Other 	
3.	Professional scope	<ul style="list-style-type: none"> a) Only exploration is covered b) Exploration and operation (geological) risks are covered c) Exploration, operation, legal and financial risks are covered d) All possible risks are covered e) Other 	
4.	Geological Scope	<ul style="list-style-type: none"> a) Fractured formations b) Sandstone formations c) Both formations d) All possible formations e) Other 	
5.	Experience sample	<ul style="list-style-type: none"> a) French b) Dutch c) German d) Swiss e) Turkish f) Mixed with Hungarian specialities g) None, a new approach is necessary h) Other 	
6.	Insurance premium	<ul style="list-style-type: none"> a) 5-8%, plus 1-3% costs b) 8-12%, plus 1-3% costs c) to be determined projects uniquely d) Other 	
7.	Risk cover	<ul style="list-style-type: none"> a) 40-60%, max amount determined b) 50-85%, max amount determined c) to be determined projects uniquely d) Other 	
8.	Scheme Operation	<ul style="list-style-type: none"> a) Sponsor determines b) Sponsor determines, with international experts c) Other 	

ANNEX VII

GeoRisk Project, WP4: Second questionnaire of the Hungarian Geothermal Risk Insurance Scheme, to be discussed in the Second WP4 National Workshop

No.	Title	Options	Remark on other issues
1.	Who should initiate the scheme from the key actors	<ul style="list-style-type: none"> g) Government, National public initiative h) Experts, geothermal professionals, insurance companies (private) i) Investors, developers or drilling companies (public or private) j) International scope k) Other 	
2.	Strategic objectives	<ul style="list-style-type: none"> g) Launching and financing with regular state supports h) State launches, then privatizing i) Public-private Partnership j) Joining an existing international Risk Mitigation Scheme k) Other 	
3.	Eligible activities	<ul style="list-style-type: none"> f) Only electricity production projects and EGS is included g) All deep geothermal projects are included h) Deep, ATES and Underground Storage projects are involved i) All geothermal projects are involved j) Other 	
4.	Geological scope	<ul style="list-style-type: none"> f) Fractured formations g) Sandstone formations h) Both formations i) All possible formations j) Other 	
5.	Insurance terms	<ul style="list-style-type: none"> i) Short term including drilling and testing wells j) Short term including the whole exploration phase k) Short and long term, including the operation phase l) Other 	
6.	Starting the operation of the scheme	<ul style="list-style-type: none"> e) Tendering processes f) Open fund, the developer applies g) Other 	
7.	Accreditation requirement	<ul style="list-style-type: none"> e) Scheme owner determines the experts and the Technical Committee and the professional level of the application documents in advance f) The earlier selected international expert team qualifies the applications separately g) Scheme owner selects expert team according to the changing tasks h) Other 	
8.	Financing form and processes	<ul style="list-style-type: none"> d) Grant, subsidized premium in advance, fee post-financed e) Warranty premium in advance, fee post-financed f) Loan in advance, repaid in case of success g) Other 	

