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GEORISK Project: 10 Years' Operation and Financial Simulation of New Geothermal Risk Mitigation Schemes in Three Target Countries

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ABSTRACT

The EU-funded GEORISK project (Developing geothermal projects by mitigating risks with financial instruments; www.georisk-project.eu) aims to promote Risk Mitigation Schemes (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.

Geothermal risk insurance funds covering the geological risk already exist in a limited number of European countries. On this basis, the project aims to promote the establishment of new geothermal risk insurance schemes in three target-countries, namely Hungary, Poland and Greece.

In this context, an important task of the project was a 10 year long-term financial and operational simulation in order to prove the financial sustainability of a proposed scheme in each of the three target-countries.

The simulation process started with the determination of the premises, involving national specialities, as presented below:

- Making decisions on the scope of the insured projects and geological structures, as well as the contract types.
- Determination of the supposition of the risk mitigation scheme, such as the insurance premium, the risk coverage and the estimated success rate.
- Calculation of the fixed costs of the scheme; scheme launching, overhead, operational and project evaluation costs.

The next step was the identification of planned projects for the following 10 years. They were recorded during the early stages of the GEORISK project. However, since the deep geothermal projects of the following 10 years have not been planned in detail so far, the majority of the data were based on realistic estimations of the well-known reservoirs.

This process was followed by drafting the operation of a 10 years' risk mitigation scheme. It is a description of the events of the projects as well as of the annual cash flows. Although an estimation, it represents a realistic operation of the RMS.

The fixed costs, the costs of the project evaluation, the revenue from cash flow calculation and the payment for the unsuccessful projects altogether provide the 10 years' cash flow.

The first draft scheme was formed with exact Hungarian suppositions and inputs of fixed costs and also with average project data, thus making it appropriate to perform sensitivity analyses on:

- insurance premium,
- success rate and
- the risk cover.

After this analysis, three complete simulations were implemented for the three target-countries; Hungary, Poland and Greece.

The paper includes the key results for all three target-countries, while focusing on the similarities and differences between them.

The presented model and simulation serves as a template for any country that aims to establish a new, financially sustainable, risk mitigation scheme.

1. INTRODUCTION, THE GEORISK PROJECT

Geothermal projects have several risky components, the most important one being the resource risk. Beyond exploration, the bankability of a geothermal project is threatened by the geological risk:

- The short-term risk of not finding an economically sustainable geothermal resource after drilling;
- The long-term risk of the geothermal resource naturally depleting rendering its exploitation economically unprofitable.

Until the first well has been drilled into the geothermal reservoir, developers cannot be sure about the exact basic parameters (temperature and flow rate) of the planned geothermal heating, cooling or electricity project. Once drilling has taken place, in situ pump tests, temperature and hydrological measurements then reduce the resource risk and make it possible to attract external capital. Risk insurance funds (risk mitigation schemes, RMS) for geothermal projects have been already operating in some European countries, namely France, Germany, Iceland, The Netherlands, Denmark, Switzerland, and Turkey. With the exception of these countries, project developers have very little capability to manage this financial risk.

The EU-funded GEORISK project (Developing geothermal projects by mitigating risks with financial instruments; www.georisk-project.eu), 2018-2021, aims to establish such risk insurance schemes all over Europe to cover the geothermal exploration phase and the first well. The risk mitigation schemes must be designed according to the market maturity of the sector and:

- Facilitate the transition of already existing insurance schemes in Europe (France, Germany, Turkey, Switzerland, Denmark, The Netherlands),
- Replicate and promote the insurance schemes for target countries in Europe (Hungary, Poland, Greece, Belgium, Croatia, Slovenia, Spain, etc.),
- Adapt and present tools in selected countries on other continents – America (Chile, Mexico, Canada) and Africa (Kenya).

One shall point out that several European countries have geothermal energy resources prospective specially for space heating, to some extent for electricity generation. They can be used on a wider scale than so far. All the more that about 5000 DH grids have been operating in the EU countries and – if geothermal heat would be introduced even only to some percentage of them – a significant effect would be achieved. According to 2019 EGEC Geothermal Market Report (www.egec.org), in 2019 about 330 geoDHs were operating in 25 EU countries and more are expected in the coming years. For this to happen, not only appropriate reservoir conditions are needed, but also appropriate support measures, including the tools aimed at mitigation the resource risk related to investment stage of geothermal projects. As mentioned above, such risk mitigation schemes (RMS) have been successfully operating in several European countries and contributed to the geothermal heating deployment.

There are also countries such as Poland, Greece, Hungary which have prospective geothermal potential for wider geoDHs' development. The geothermal heat markets in these countries can be treated as juvenile ones or in transition, so up to now the main measures of supporting these markets' development are public grants and / or loans. In line with the expected development of these markets, it is necessary to introduce other appropriate supportive tools, including RMS. Initially they should be of a public type. Considerations, discussions with various stakeholders and proposals directed to decision makers in this regard have been ongoing in several countries. The introduction of appropriate supportive and de-risking measures tailored to the stage of geothermal heating market's development should stimulate their development. This applies also to the above-mentioned three target countries, where, apart from grants and loans, the public risk insurance fund will be the most appropriate tool in the near future. So far no such funds have been established in these countries.

The parameters which appear suitable to build the RMS simulation tool are to:

- Evaluate the CRI (Commercial Readiness Index) for the targeted country;
- Establish a system as sustainable as possible through a Private-Public-Participation, even if the public funding for launching the operations represents nearly 80%;
- Cover a significant amount of the CAPEX financed by the developers in case of failure; the coverage should not be lower than 60% and should preferably approach 80%;
- Maintain a premium at a level as low as possible, to encourage the developers to subscribe and promote pooling; a range in between 5 and 10% appears worldwide to be manageable;
- Establish a funnel for each country with a minimum of potential plants in a ten-year period, in order to dimension a system with sufficient size and maximum participants.

There are over sixty risk events collected in the Risk Register of the GeoRisk Project. They all could be covered in the risk mitigation schemes. However, in the simulation activities, the focus was put on the success of exploration. It corresponds to the experience of former and ongoing schemes. Definitions of success, partial success and failure need to be precisely defined for each specific RMS. On this basis, the degree of non-compliance with the project assumptions will be estimated. As a result, the amount of reimbursement will be estimated. The article presents a simulation of refund to geothermal developers in a situation of complete failure of a drilling project.
The financial basis of the reimbursement to the project developers is a public fund that is to be privatized after the development of the geothermal energy market. Then the reimbursement can be financed from the collected insurance premium.

Within the framework of the GEORISK project, following the good practices of already operating risk insurance funds for geothermal projects in some European countries, the 10 years' simulations of the sustainable operation of such funds were conducted for Hungarian, Greek and Polish cases. The expected realistic number of geothermal projects within 10 years' perspective in each of these countries were assumed (based on a survey aimed at identification of ongoing and possible geothermal projects), as well as several variants of other basic factors (i.e. founders, initial capital, premium fees, success rates, etc.). The results, conclusions and recommendations should be important for potential investors, decision makers, financing institutions, insurance companies, etc. They are briefly presented in this paper.

2. OBJECTIVE AND APPROACH OF THE SIMULATIONS

2.1 Objectives

The general objective of the financial simulation is to calculate 10 years' cash-flow of a planned Risk Mitigation System. In order to calculate a cash-flow, it is necessary to determine the operation actions that affect cash-flow. These actions depend on the premises of the RMS. Therefore, the establishment process follows the steps below:

- Determine the
    - legal forms of the risk mitigation projects,
    - the aimed technical issues (risks) and the
    - operating forms of the Risk Mitigation System Management.
- Then estimate
    - the suppositions of the key influencing parameters of the risk mitigation projects and also
    - costs of the System Management.

Having determined and calculated all these inputs, the simulation can be run. We can determine the financial level of the key parameters in order to set the System operation financially sustainable, or we can determine the financial support demand on 10 years' term.

2.2 Approach

GEORISK Project included three National Workshops in all target countries:

- to collect the opinion of the key stakeholders,
- inform them about the results of the project Work Packages and
- discuss the pending issues of the establishment of the RMS.

Two questionnaires were issued to the stakeholders to collect their ideas and interests related to the RMS. The questionnaires were evaluated and decisions were made on the following aspects:

- Risk Mitigation Project types
- Geological structures to be aimed
- Available contract types
- Hypothetical possibilities

Moreover, after the evaluation of the questionnaires and the discussions, the suppositions of the key parameters insurance premium, risk cover and estimated success rate could be adjusted to a realistic rate.

The first simulation was prepared to the Hungarian case and – to make it as simple as possible – we calculated the cash-flow with average project data and also with basis premises: 30 projects in 10 years, Insurance premium: 10%, Risk cover: 75%, Estimated success rate: 90%.

10 years cash-flow

with Hungarian basis premises

Total Assets	at the end of year, €
Year 1	10 735 000
Year 2	9 100 000
Year 3	9 745 000
Year 4	10 390 000
Year 5	8 710 000
Year 6	9 355 000
Year 7	10 000 000
Year 8	8 320 000
Year 9	8 965 000
Year 10	9 610 000

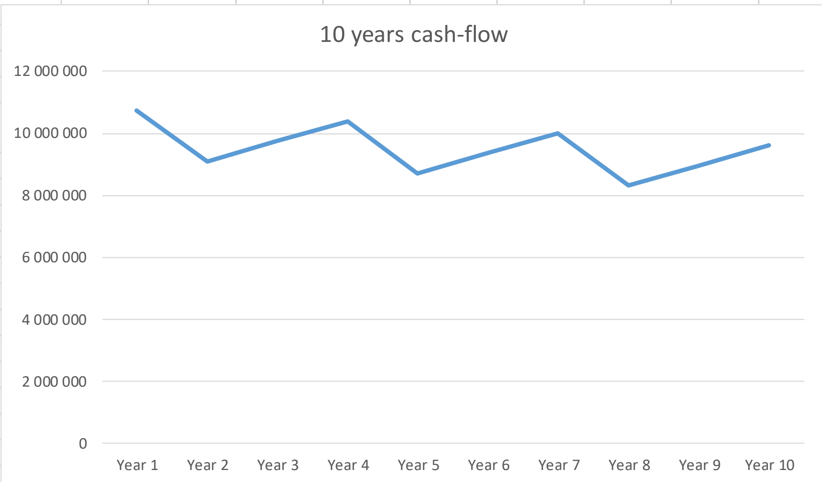

Figure 1: The Hungarian case with average project data and basis premises

It is a model of a sustainable RMS. However, this case is too pure and 10% insurance premium is rather high, therefore we analyzed the model by its key parameters.

2.3 Analyses by key parameters

10 years cash-flow

Analysis by premium

Total Assets	Premium 10%	Premium 8%	Premium 6%	Premium 4%
Year 1	10 735 000	10 549 000	10 363 000	10 177 000
Year 2	9 100 000	8 728 000	8 356 000	7 984 000
Year 3	9 745 000	9 187 000	8 629 000	8 071 000
Year 4	10 390 000	9 646 000	8 902 000	8 158 000
Year 5	8 710 000	7 780 000	6 850 000	5 920 000
Year 6	9 355 000	8 239 000	7 123 000	6 007 000
Year 7	10 000 000	8 698 000	7 396 000	6 094 000
Year 8	8 320 000	6 832 000	5 344 000	3 856 000
Year 9	8 965 000	7 291 000	5 617 000	3 943 000
Year 10	9 610 000	7 750 000	5 890 000	4 030 000

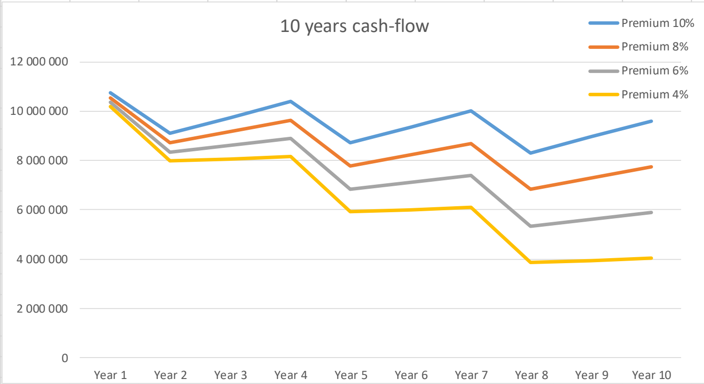

Figure 2: Analysis by key parameters: premium

Premium influences strongly the financial sustainability of the system. 10% seems to be enough to maintain the assets of the Fund. However, in case of 4% or less, the Fund is to be supported in every decade, so the determination of the premium is a strategic question.

10 years cash-flow

Analysis by risk cover

Total Assets	Risk cover 75%	Risk cover 80%	Risk cover 60%	Risk cover 50%
Year 1	10 735 000	10 735 000	10 735 000	10 735 000
Year 2	9 100 000	8 945 000	9 565 000	9 875 000
Year 3	9 745 000	9 590 000	10 210 000	10 520 000
Year 4	10 390 000	10 235 000	10 855 000	11 165 000
Year 5	8 710 000	8 400 000	9 640 000	10 260 000
Year 6	9 355 000	9 045 000	10 285 000	10 905 000
Year 7	10 000 000	9 690 000	10 930 000	11 550 000
Year 8	8 320 000	7 855 000	9 715 000	10 645 000
Year 9	8 965 000	8 500 000	10 360 000	11 290 000
Year 10	9 610 000	9 145 000	11 005 000	11 935 000

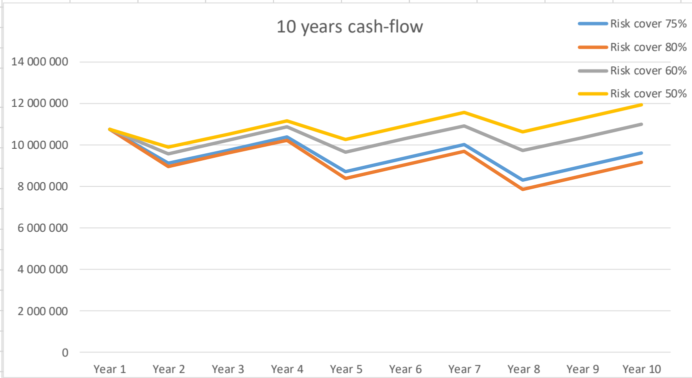

Figure 3: Analysis by key parameters: risk cover

The determination of risk cover is mainly important for the project developer; they have to finish the project from this amount. Therefore, it is a chiefly technical question, depends on the costs of the technological solutions.

10 years cash-flow

Analysis by success rate

Total Assets	Success Rate 90%	Success Rate 80%
Year 1	10 735 000	10 735 000
Year 2	9 100 000	9 100 000
Year 3	9 745 000	7 420 000
Year 4	10 390 000	8 065 000
Year 5	8 710 000	6 385 000
Year 6	9 355 000	4 705 000
Year 7	10 000 000	5 350 000
Year 8	8 320 000	3 670 000
Year 9	8 965 000	1 990 000
Year 10	9 610 000	2 635 000

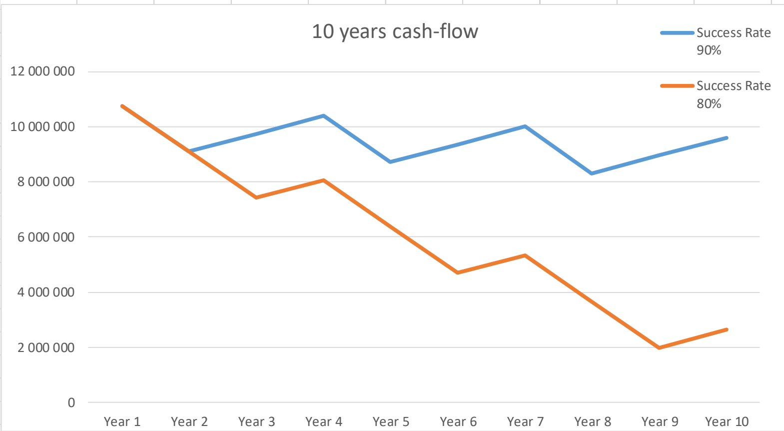

Figure 4: Analysis by key parameters: success rate

As it was expected, the success rate is the most sensitive parameter. A key strategic expectation is to maintain the 90% success rate (one from ten projects has a failure) in order to achieve the financial sustainability. Below this rate regular funding is necessary.

The next step of the simulation process was to simulate an RMS cash-flow separately in the target countries with their own legal, financial and natural background as well as with their expected projects.

3. SIMULATIONS FOR THE TARGET COUNTRIES

3.1 Hungary

Hungary is a well explored country with more than 8000 hydrocarbon and 1000 geothermal wells. The database of these wells ensure enough geological and geophysical data to prepare fairly detailed regional and areal underground analyses. Therefore, only extreme deep (5 – 6 km) EGS projects belong to highly risky projects.

Based on the opinion of key stakeholders, the selected premises were taken into consideration:

- Risk Mitigation Project types: All deep geothermal projects are included. Short term contracts, including drilling and testing wells,
- All possible geological structures are to be aimed,
- The preferred contract type: Grant, subsidized premium in advance, fee post-financed.

The planned launching amount was 10 million euros. The system operating costs included the costs of the Fund, the Secretariat, Technical Committee and the Experts. The draft operating chart of the planned RMS is similar to the operating French system.

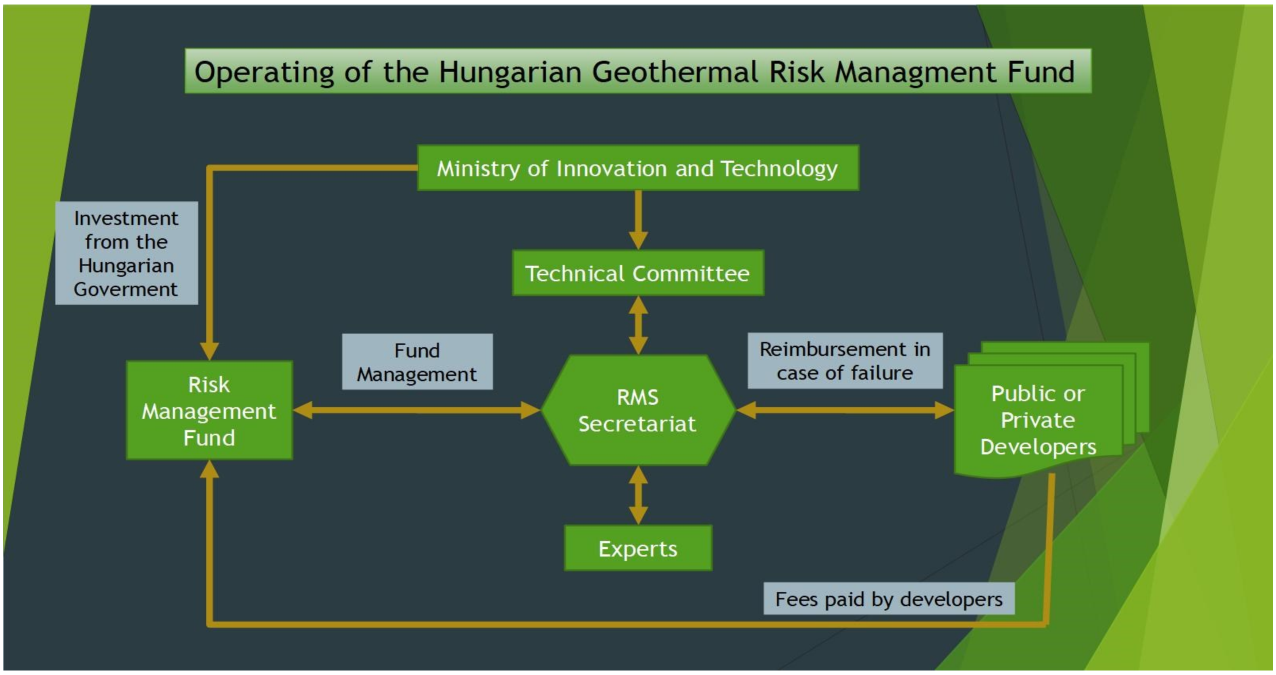

Figure 5: The recommended operation of the Hungarian Geothermal Risk Management System

30 expected projects were selected into the simulation of the following 10 years. The simulation was run with these not fully planned, but realistic project data. The result was similar to the case with average project, because the key premises were the same: Insurance premium: 10%, Risk cover: 75%, Estimated success rate: 90%.

10 years cash-flow

With the Hungarian expected project costs

Total Assets	at the end of year, €
Year 1	10 435 000
Year 2	8 375 000
Year 3	8 800 000
Year 4	9 445 000
Year 5	7 825 000
Year 6	8 800 000
Year 7	9 545 000
Year 8	8 250 000
Year 9	8 905 000
Year 10	9 610 000

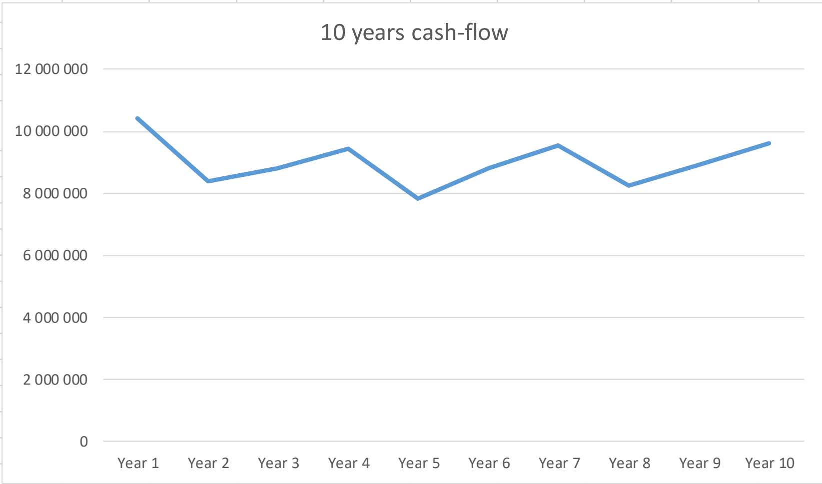

Figure 6: The Hungarian case with the expected realistic 30 projects in the following 10 years

It is an opportunity if the sponsor of the system wishes to operate a financially sustainable Geothermal Risk Management System.

3.2 Greece

The geological conditions in Greece resulted in the natural occurrence of a significant number of geothermal fields, corresponding to an important geothermal potential. However, its utilization is rather limited, as it is exploited completely for low enthalpy (<90 °C) direct heat uses, and total absence of electricity generation plants. Hence, the aim of the establishment of a risk mitigation scheme in Greece would be to “unlock” private investments in the geothermal sector, and particularly for medium (100-150 °C) and high enthalpy (>150 °C) applications.

Until now, more than 55 geothermal fields have been identified in total, distributed across Greece. However, their level of exploration differs significantly. Geothermal resources proven by wells taping their reservoir are recognized by national legislation and correspond to two high enthalpy (>300 °C) ones (Milos and Nisyros islands), and several low enthalpy (<90 °C) ones, located mainly in the Northwest part of the country. Having this in mind, the performed simulation treats differently the estimated success rate of each potential project; hence the initial success rates taken into account consist of: 90% for high enthalpy proven fields (Milos and Nisyros), 67% for high enthalpy unexplored fields (Chios, Lesvos, Methana, Sousaki, Samothraki, and Thera), and 90% for proven low enthalpy fields (Akropotamos, Aristino, Erasmio, Erateino, Heraklia, Nea Kessani, Nigrita, Sidirokastro).

The development assumes drilling, completion and operation of one successful doublet in each one the above high enthalpy fields for power generation and 3 successful doublets in each one of the above low enthalpy fields for district heat supply. A number of failed wells are also considered based on above success rates. Indicative well costing was done based on local geologic and reservoir conditions, with rather conservative estimates, being in the lower part of the cost range. Each insured project comprised one well, either production or reinjection.

The 10 year simulation for Greece was carried out based on a scenario including the drilling and completion of 55 production and reinjection wells in the abovementioned fields –with the corresponding success rate in each case, and with an initial capital of € 10 million for the insurance fund. In this context, the 10 year cash flow was calculated, on the basis of different combinations of insurance premiums (8, 10 and 12%) and risk coverages (65, 75 and 85%). Figure 7 presents the relevant results of the nine different scenarios; it should be noted that when taking into account the specific success rates (90%/67%/90%), the insurance scheme is financially unsustainable for the specific pairs of premiums and coverages, making it clear that in all cases the total assets’ balance is represented by a negative-slope trendline. However, a distinction should be made between the cases where the scheme has still enough funds to operate after 10 years, compared to the cases where the scheme has financially “collapsed” before the 10-year mark.

Figure 7: 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

Having examined the effect of different rates of coverage and premium, the next step was to evaluate the impact that different success rates of the projects could have on the 10 year cash flow of the presented scenario. Having this in mind, four cases where prepared: the three of them maintained same success rate 90% for all proven fields, high enthalpy and low enthalpy ones, with different values of the success rate (50% - 67% - 75%) examined for the high enthalpy unexplored fields; the 4th scenario assumed that geothermal developments will take place only in proven fields, either Milos and Nisyros high enthalpy ones or the low enthalpy fields, with corresponding success rate equal to 90%. In all cases, premium and coverage rates were held constant, 10% and 75% respectively. Undoubtedly, the effect of the projects' success rate plays the most important role in the overall sustainability of the insurance scheme; as presented in Figure 8, a scheme based on the overall 90% success rate scenario could be even characterized as financially sustainable (capital of approx. € 9,9 million after 10 years of operation). On the contrary, a scenario of 50% success rate for the high enthalpy unexplored at present fields would lead the scheme to fall apart after the 7th year of operation. Of course, it should be noted that the particular evolution of the cash-flow in each scenario depends also on the years that the projects are assumed to fail (based on corresponding success rate); assuming the existence of failed developments in different years throughout the 10-year period could lead to different cash-flow which, in any case, would eventually have the same result ± 2 years.

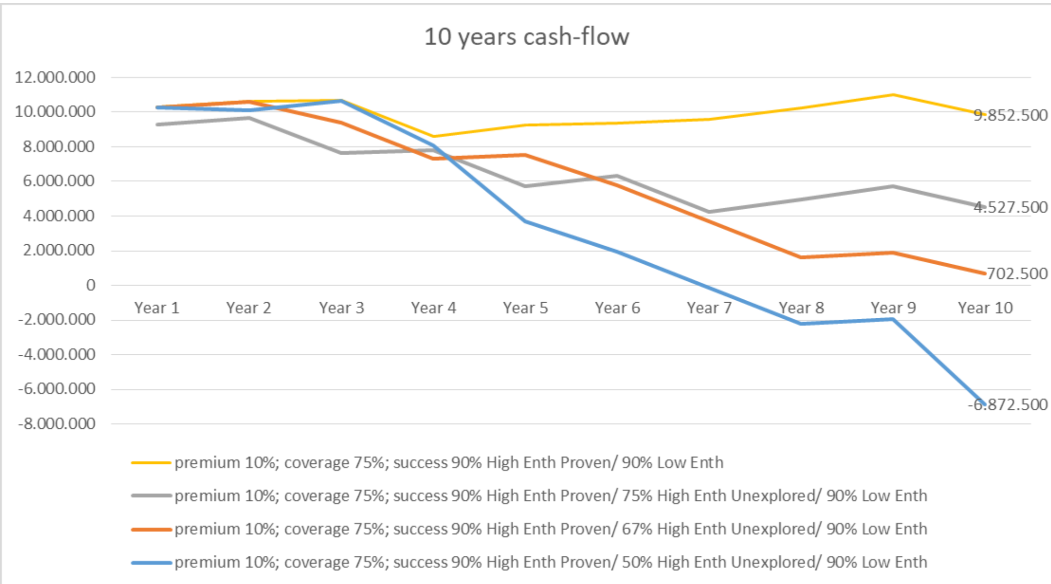

Figure 8: The Greek case: effect of different success rates on the 10 year cash-flow

Based on the above analysis, some initial results could be indicated. As previously mentioned, a € 10 million scheme with a 10% premium and 75% would not be financial sustainable, as after 10 years less that € 1 million would remain in the fund (90%/67%/90% success rates scenario). However, such a scheme would make sense to be launched as a public fund, in the context of a 10-year development policy for the Greek geothermal sector. In addition, in case the insurance premium (10% in the examined case) is considered as rather high to be covered by the private developers, a 50% public subsidization of the premium could be also provided, as a policy measure towards geothermal development. Indeed, such a public scheme [€ 10 million + 50% premium subsidy (i.e. 5% premium in the specific case)], would lead to a significant leverage of public investment towards geothermal development, equal to

6,21, as, based on considered scenario, € 83,65 million of total funds will be mobilized, by € 10 million public fund, plus € 4,1825 million premium subsidization minus € 0,7025 million residual funds after 10 years.

In case the aim is to launch a private fund, based on the specific conditions, a premium not less than 21% (according to conducted sensitivity analysis; not presented within this article) should be applied, in order to maintain at least financial sustainability (i.e. fund approx. € 10 million after 10 years of operation). In this case, and having in mind that an acceptable premium for the private developers would be around 5%, the public should subsidize the remaining 16 percentage points, in the context of a geothermal market acceleration policy. In this case, a public funding of € 13,384 million would lead to € 83,65 million as private investments in geothermal projects, hence a leverage of 6,25 would be achieved (approximately the same level with the case of the public fund proposed above) . Of course, this 21% premium would be adequate only to reach the profitability threshold, meaning that a private scheme would of course require a higher premium, *ceteris paribus*.

With that said, it should be indicated that different preconditions concerning the premium, coverage and success rates would of course lead to different financial requirements and results concerning the initialization of a public or a private fund, either assisted or not by a public risk premium subsidization scheme.

3.3 Poland

According to the published information (eg. Dziadzio et al., 2020) and derived from other sources in the coming 2020-2030 decade one may expect in Poland (with various probability level) the implementation of up to 40-60 geothermal projects targeting district heating, heating and other direct applications. However, some of already ongoing and potential projects (specially aimed at geoDHs and heating) will be implemented only when non-repayable public grants will be awarded. Since 2016 several big public priority programs offering such forms of support have been launched (www.nfosigw.gov.pl), like Geology and mining (by 2019), Polska Geotermia Plus (since 2019), Accessing geothermal waters in Poland (since 2020), FM EEA Constructing heat sources using geothermal energy (deep geothermics) (since 2020). In the next years local governments – which would be main beneficiaries and implementers of geoDHs' projects – will most likely not be interested in the geoDHs' development, if no public non-repayable grants are available (which take over the financial risk from entrepreneurs in case of unsuccessful drilling and not finding proper geothermal resource). Taking this possible situation into account, 20 and 30 from the identified larger number of potential projects (drilling the wells) were assumed as a basis for 10 years' operation simulation provided they are not eligible for public support in the form of non-repayable grants – and will be financed in other forms and from other sources. In this case a public risk insurance fund is an appropriate tool for these projects' de-risking, attractive for the group of other potential investors (private, etc.) interested in entering the geothermal heating market.

The results of 10 years' operation simulation are presented in this section for the following assumptions (the most probable under geological end economic conditions as well as a stage of geothermal heat market development in Poland):

- launching amount of the fund of 11.28 million €, which is three times the average cost of drilling a geothermal well, estimated on the basis of the value of drilling projects qualified for public non-repayable grants and loans (average depth ca. 2606 m),
- number of wells being insured: 20 and 30 in the 10-years' perspective,
- success rate: 80% (16/4 and 24/6 successful or/unsuccessful wells, respectively),
- insurance premium: 4, 6, 8 and 10%,
- risk cover: 70% and 75%,
- time span of the geothermal drilling project: 3 calendar years,
- overhead costs of the RMS: 150 000 €, annually.
- project expert cost: 10 000 € per ongoing project, annually.

The analysis of the operation of the proposed risk insurance fund for geothermal projects is presented in Figures 9 and 10, for 20 and 30 covered projects, respectively. In almost every case, the fund's base amount, supplemented by contributions by geothermal developers (insurance premium) would allow even 75% reimbursement of incurred costs to those projects that would fail (assuming a success rate of 80%). Only in exceptional case the fund assets would be totally used before the end of 10-years perspective (4% premium, 75% risk coverage; 3 projects/year). Such a solution should be encouraging both for private and other investors (other than local governments, most likely) and for state bodies that would set up the fund, not only due to increasing the chances of a larger number of geothermal drilling projects being developed, but also due to reducing the involvement of public funds. At this same time these would bring significant leverage effects: 8.00€ investment/ 1€ public in case of 24 positive projects and 5.33€ investment/ 1€ public in case of 16 positive projects (success rates 80%).

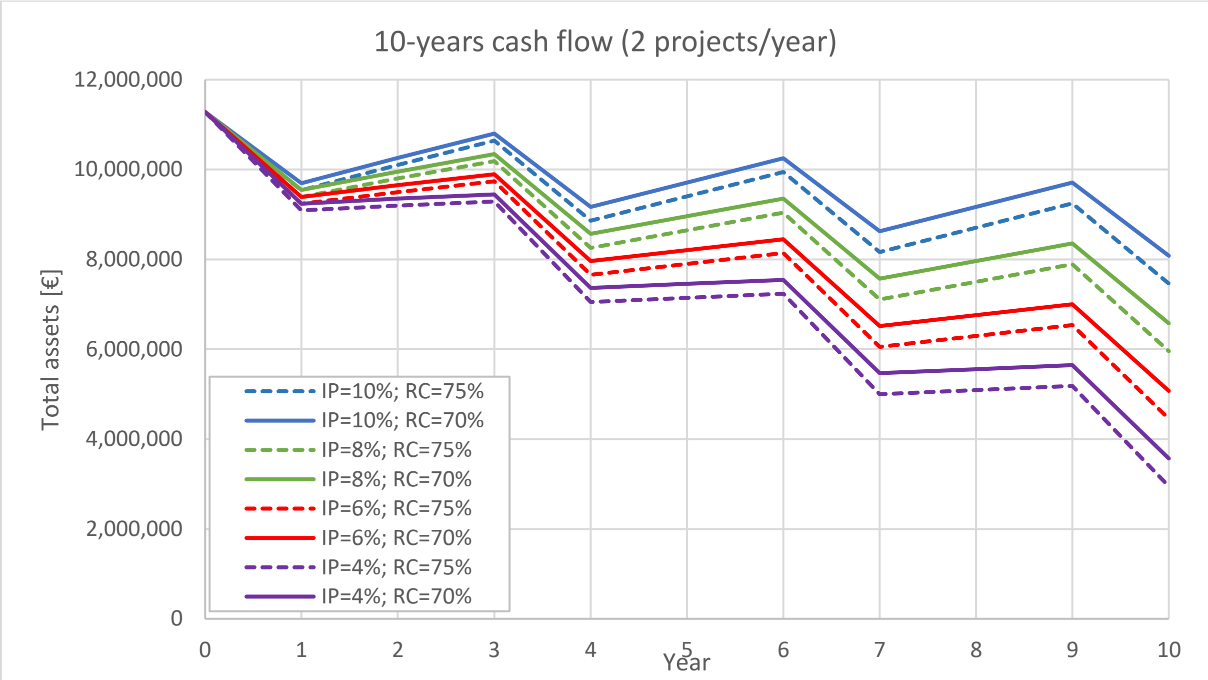

Figure 9: The Polish case: 10-years' cash flow of the proposed risk insurance fund for geothermal projects: 2 projects/year with a success rate of 80%, 20 projects. IP – insurance premium, RC – risk cover.

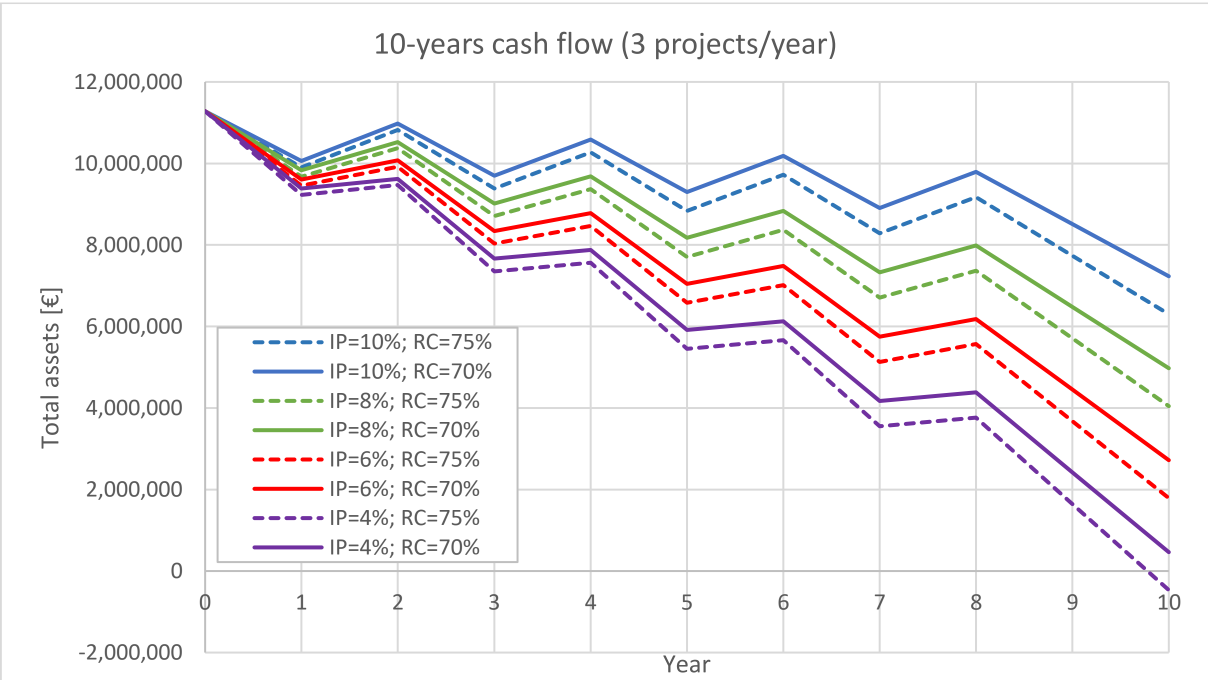

Figure 10: The Polish case: 10-years cash flow of the proposed risk insurance fund for geothermal projects: 3 projects/year with a success rate of 80%, 30 projects. IP – insurance premium, RC – risk cover.

3.4 A country with a long RMS experience: France

The late 1970s saw the birth in France of a heat producing industry built on the use of vast geothermal resources located 2,000 metres under the Greater Paris Region. This home-grown source of energy at a time when the price of fossil fuels was exploding, in the wake of the first oil crisis of 1973, offered temperatures of 60 to 85°C, therefore directly usable for heating residential complexes with or without shared heating networks.

In the early 1980s, a mechanism for covering geological hazards was set up, initiated by the Ministry of Industry with, in 1981, the creation of the Long Term Guarantee Fund to cover the operating life of geothermal works. This duration was initially planned to last

for 15 years (before later being extended to 25 years). The fund was managed by SAF-Environment. A subsidiary of the Caisse des Dépôts et Consignations a state bank.
If low temperature geothermal energy is what it is in France today, with – despite the infancy troubles encountered – a large number of operations kicked off some 35 years ago and still in operation today, this is thanks to public support and to the technical expertise developed progressively by the operators. It has also become what it is, thanks largely to the determining part played by the guarantee mechanisms put into place.
Regarding the guarantee mechanism created in the early 1980s, we need to stress the usefulness of such a mechanism in relation to the public purse.
Hence, for the Short Term Fund, investments worth €198 million were guaranteed for the drilling phase, with €4.7 million paid by the public purse to the Funds, which means that for every €1 paid by the State, €42 of investments were guaranteed.
Lastly, with this guarantee tool that was both a forerunner and a rather innovative one, France gained real life experience that can easily be transposed outside of France, as was the case with the Netherlands a few years ago. Although the production of geothermal heat is coming second in renewable energy contributions to heat production worldwide, widely distributing this experience would no doubt allow further increasing its contribution.

In the framework of the GEORISK project, it was interesting to benchmark the tool built in the framework of the WP 4 and dedicated to the establishment of the size, level of coverage, success rate and premium to be established in order to build the more perennial RMS possible.
For France the real numbers have been used for 30 geothermal District heating doublets in ten years. The real success rate at 90% learned from more than 240 wells drilled before the average normal, cost of one doublet at around 10M€ for the sub-surface costs (mainly drilling costs) and a premium low at 3.5% representing a charge of 350 K€ per insured doublet.
The figure below shows that operating simulation of the RMS is rather close to the 35 years of the existing fund with the need in a period with low inflation to refuel the fund after 11 to 12 years of operation. In that case the impact of the RMS is huge with 8 M€ financed by the French state for a total investment in geothermal of about 300 M€ which shows a very effective leverage effect of the public grant.

Ten years operating symulation of the existing French fund
Geothermal Risk Mitigation Scheme

10 years cash-flow

First draft

Total Assets	at the end of year, €
Year 1	10 000 000
Year 2	6 960 000
Year 3	7 690 000
Year 4	8 420 000
Year 5	4 650 000
Year 6	5 380 000
Year 7	6 110 000
Year 8	2 340 000
Year 9	3 070 000
Year 10	3 800 000

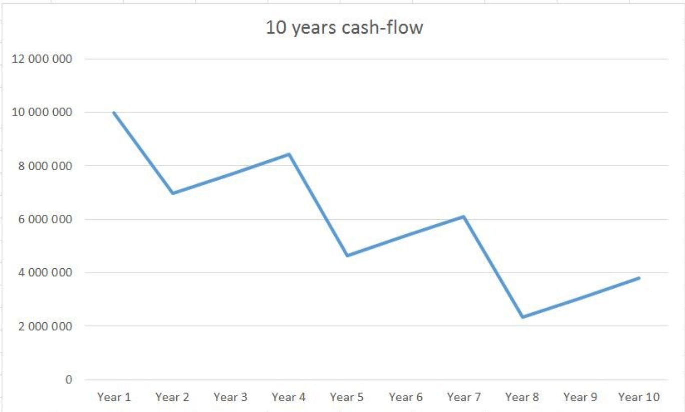

Figure 11: The French case: 10-years operating cash flow with 3.5% premium

4. SUMMARY OF THE SIMULATIONS

The cases above prove that the sustainability of the geothermal risk mitigation systems is well calculable. The calculations show the possibility of the sustainability or the support necessity.

Analyses in all countries demonstrate the significance of the high success rate as the most sensitive factor of the RMS sustainability. A system may be launched and operated only if the highest possible success rate is ensured. However, the premium also affects strongly the cash-flow of the system.

There are a lot of similarities among the simulation results of the target countries. The key factors behave the same way and their role has the same importance in the sustainability of the system.

Beside the similarities there were differences in the simulations as well. Greece have different natural conditions than Hungary and Poland. The Greek simulation provided an interesting example, how to handle the well-known and unexplored areas, as well as the fields with high, medium and low enthalpy in a different way.

The operating and cash-flow simulation as well as its results ensure wide range support in the decision making process related to launch a new geothermal risk mitigation system.

5. RECOMMENDATIONS TO ESTABLISH NEW RISK MITIGATION SYSTEM

An RMS is a very effective way to support the geothermal sector and after a transition time it can be privatized. Therefore, it has to be an important tool for supporting the geothermal sector.

During the planning of a new RMS it is important to take into consideration the long experience of the former and existing systems.

Not only the establishment a new system can be the most practical way. There will be more and more systems. Joining an operating system can be a useful solution as well. The operating system has an interest to involve new projects in order to achieve lower overhead costs.

In order to push the overhead costs and the premium to the lowest level, establishing larger international RMS seems to be more and more feasible, and a European Geothermal Risk Mitigation System is already to be considered.

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