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Geothermal Project Development in Germany - First Corporate Investors Enter the Market

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ABSTRACT

Geothermal energy is thought to play a decisive role in the future global energy supply. As it comes up with considerable risks and challenges, however, the development of geothermal resources has been slow in many countries in the past. In Germany there has not been a privately funded geothermal power project until the end of 2007. Nevertheless, geothermal power projects present considerable chances to investors which lead to a first privately funded project at the end of 2007 initiating an increasing implementation of geothermal projects.

1. INTRODUCTION

Evolving from its niche existence, geothermal energy little by little carries weight in the discussion of a modern global energy supply and begins to shape its advantages compared to other renewable energy sources. National policies – especially from nations with significant geothermal potential – increasingly consider geothermal energy in their future supply scenarios. However, for its further growth it is inevitable that private enterprises get involved in the global development of geothermal power projects to accelerate their implementation. Their involvement depends on the assessment of the projects´ risks and chances, i.e. the market framework conditions. The German geothermal market – as this paper underlines – is just about to be increasingly developed by private investors which adapted their business approach to the geothermal challenges and make use of the German Renewable Energy Act.

2. GERMANY´S GEOTHERMAL ENERGY MARKET

In Germany only a few projects had been realized. The existing projects had been set up by public services and research institutions only and mostly were declared to be demonstration projects. The majority of these projects, such as Pullach and Straubing, had been designed to deliver heat only. Besides the research plant in Neustadt-Glewe power projects had not been realized. Most activities are situated in the southern German Molasse basin, where usually two wells with depths of 2 km to 5 km depth are constructed to extract and re-inject thermal water from its hydrothermal reservoir with flow rates of about 50-150 l/s and temperatures of 80-150°C. The fluid has to be pumped to the surface as there are no significant artesian geothermal reservoirs in Germany. The thermal water is circulated in a closed loop at the surface and transfers its energy to power plants (binary cycles) or heating facilities by heat exchangers before it is re-injected into its reservoir again.

In the past corporate investors hesitated investing into geothermal projects as the market conditions including the risks exposure and the stock of experiences were poor and the projects did not generate a risk adequate return. Only after the conditions had been improved project development and implementation became attractive. However, the financial crisis 2008/2009 counteracts this acceleration.

2.1 Risks of Geothermal Projects

Geothermal power projects are related to a number of risks that prevalently can be neither mitigated nor insured and therefore have to be borne by the developer or investor. Table 1 exemplifies the major risks in relation to project progress.

Table 1: Matrix of risks in deep geothermal projects in relation to project progress

Risk in …	Resource Development	Plant Erection	Plant Operation
…geology	high		
…drilling	high		
…productivity	high		
…construction		low (ORC)	
…operation			low (ORC)
…political background	low	low	low
..energy sales			only for heat/cold: low

As deep geothermal projects aim at reservoirs that are located some thousands of meters beneath the earth´s surface, at least in Germany, geology accounts for maybe the most significant part of the projects´ risks and causes subsequent risks. The existing data basis of geological information often reaches only into depths of some hundreds or in better cases the first thousands meters. However, geothermal target horizons are regularly situated in greater depths so that additional exploration effort has to be applied. Excellent exploration can significantly reduce the risk based on geology. However, in the end the saying of German miners “Vor der Hacke bleibt es duster”, (in front of the pick-axe it remains dark) does not lose its sense. Deviation from stratigrahic or petrologic forecasts and the misinterpretation of fracture zones are amongst others summarized under geological risks.

Based on the geology, the drilling is fraught with tangible risks. If the assumed geological conditions vary significantly from the in-situ situation, drilling is at risk of time delays and cost increases as probably not the right materials and tools are applied to develop the reservoir. Summarized under drilling risks one can find also the risks that equipment is lost in the well (lost-in-hole), the well itself collapses or differential sticking occurs. These risks are based on a mixture of geological and technical risks. In the worst case these risks can result in the abandonment of a well section or the whole well.

The second core issue regarding subsurface risks is the productivity of the reservoir. Once the reservoir has been developed, it has to be proven that it delivers the assumed parameters as basis for all economic evaluations. These parameters are the flow rate related to the well´s drawdown, the wellhead temperature and the quality of the extracted water when open systems, e.g. doublets, are applied. Although there do exist ways to stimulate a reservoir to increase its productivity by acidification or hydraulic injections, the in-situ geology is the dominant factor for the productivity. If productivity cannot be proven after drilling and subsequent stimulation, cost-intensive contingency measures (e.g. drilling of a side track) or the abandonment of the well are to be taken into consideration.

A specialty of these subsurface risks is that they prevalently have to be borne by the developer and cannot be transferred to any contractor. This is reflected as well in the fact that drilling contractors and service companies only work on day rate basis.

After the successful development of the reservoir the construction of the power or heat plant is in comparison to the subsurface works of limited risk. A weak spot, however, is the missing experience in the field of geothermal energy systems.

In addition to the significant risk of resource development and the limited risk in plant construction there have been identified risks in the operation of the plants as far as availability is concerned. These risks are not related to the systematic approach (pumping water in a circuit and extracting heat by heat exchangers) itself, but to the quality of the circulated thermal water.

For German projects, the core element of the thermal water loop is the pump to extract the water from its deep reservoir and re-inject it again. The high fluid temperature and flow rate, along with the significant delivery height of some hundred meters, place great demands on the pumping technology which to some extent cannot be met by current standard products. This limits the capacity of the pump and could as well endanger a high availability of the total system in the operation period with direct impact on the sale revenues.

Furthermore, the thermal water circuit itself is fraught with risk of failure. Depending on the water´s quality, corrosion, precipitation or degassing may affect the availability of the circuit or might lead to increased maintenance efforts with extended or unplanned shut down times. Especially heat exchangers are fragile as they are subjected to clogging when water with high concentration of minerals or unsolved substances is pumped.

Depending on the enthalpy of the geothermal fluid, various power generation systems can be applied and combined to achieve a maximum of efficiency. In Germany with its low temperature reservoirs, only binary cycle processes, such as ORC or Kalina, can be applied. So far, the German market comes up with little experience in the commissioning of these plants. With regard to long-term operation there is no experience. Therefore availabilities of the plant can be transferred from foreign projects only and have not been experienced in the German market.

The long-term capacity of reservoirs has not been tested either. Reservoir modeling is done for single projects but there is no practical experience regarding the impact of an increasing number of projects on a reservoir or how adjacent projects affect each other. This discussion is reflected in an unclear interpretation of the mining law for geothermal exploitation concessions.

2.2 Challenges of Geothermal Projects

Besides these risks – either based on little experiences, geological uncertainty or technological limits – the development of geothermal power projects comes up with further challenges.

The development of a reservoir and the subsequent erection of the power plant demand significant investments. For a standard system of a doublet and a power plant in Germany an investment volume of approx. 45 Mio. USD is estimated of which more than 60% is spent even before productivity can be proven. Due to the mentioned risks, the availability of project financing is very limited and at the moment not accessible at all for resource development. This leads to the necessity that the project developer gets committed with up to 100% equity in the projects. This certainly has been a significant barrier for the development of geothermal projects in Germany in the past years and led to a slow market development which has been dominated by public institutions such as municipalities and R&D facilities. Privately financed projects have not been realized until the end of 2007.

A further challenge developers have to deal with is the availability of geothermal exploration concessions. According to the German mining law exploration depends on regulatory permissions. At least for the promising German reservoirs, most of the concessions were already awarded to developers. As only every two to three years a re-evaluation is conducted, the availability of concession is supposed to be low for the following years.

Another shortage occurs in the availability of drilling rigs and qualified staff as the next challenge. There are providers of conventional rigs and providers of geothermal-specific rigs. But as the petroleum industry increased its demand and the production capacity is rather limited, the availability of rigs for geothermal projects was very restricted as well. Furthermore, geothermal projects contract rigs for only one project with 2-4 drillings whereas the petroleum industry offers long-term contracts. This gives a competitive advantage to the petroleum industry in acquiring rigs.

Moreover, to operate a drilling rig, well-trained and compulsory certified professionals are required. Again a geothermal developer has to directly compete with the petroleum industry. As the qualification of rig staff is complex and subjected to certification, the availability of excellent staff is low and the staff that can be acquired is reasonably expensive.

However, with the decreasing demand during the financial crisis these shortages have been weakened slightly.

Although it is often said that geothermal business is very similar to the petroleum business geothermal stands out with some issues. Compared to the geothermal industry the petroleum business can compensate exploration failure more easily as the petroleum reservoirs outvalue geothermal reservoirs by far. Failure in the geothermal business might lead to the end of a project and endangers the fragile development of the new geothermal market in Germany.

2.3 Chances in Geothermal Projects

Besides the substantial risks and challenges there are compensating chances geothermal developments come up with. Geothermal energy is a renewable energy source. In comparison to other renewables, however, it can supply electricity and heat/cold on a base load level with virtually no emissions and a significant worldwide potential. This makes geothermal energy to a viable alternative to fossil energies in the centralized and decentralized energy supply and hence increases its attractiveness.

These favorable facts are represented in an increasing number of governmental policies on future energy supply scenarios containing geothermal energy. Especially countries with huge potential do include geothermal energy into their renewable energy laws to foster its development. So did Germany when it published its Renewable Energy Act. This act established fixed tariffs for electricity generated from geothermal sources which are paid for 20 years. Consequently it guarantees cash-flows without any risks in volume and tariff for a period of 20 years to the developer.

The amendment of the act that came into effect in 2009 introduced an increased basis feed-in tariff of 16 ct/kWh and various bonuses as Table 2 indicates. Projects entering operation before the end of 2015 receive additional 4 ct/kWh. For the implementation of innovative technologies and a significant sale of heat further bonuses are available. The basis tariff and the bonuses are reduced by 1/100 each year based on 2009. Thus, a project starting operation in 2010 obtains 19,8 cent for each kilowatt-hour of electricity generated from geothermal energy. These subsidies are the main driver in speeding up geothermal developments and attracting private project funding. The German Renewable Energy Act is reviewed every two years and, based on the current political support, it is not expected that the tariffs will decrease in the future.

The introduction of the EEG and its amendment can compensate the threats of risks and other project challenges and render geothermal power projects economical viable. Therefore the implementation of the first entire privately funded project – Dürrnhaar – started at the end of 2007 followed by the second project – Kirchstockach – at the beginning of 2008.

3. CASE STUDY: FIRST PRIVATELY FINANCEND PROJECT REALIZATIONS IN GERMANY

Within a joint special purpose vehicle (SPV) HOCHTIEF PPP Solutions (Essen, GER), Renerco Renewable Energy Concepts (Munich, GER) and SachsenFonds (Haar, GER) teamed up for the exclusive development, financing, execution and operation of a series of geothermal power plants in the Molasse basin. HOCHTIEF provided a drilling rig including the rig service and its competences as infrastructure developer. Renerco contributed with its in-depths knowledge and local networking. SachsenFonds finally supplied a number of promising exploration concessions allowing a series of at least ten plants. The aim was set to start two projects each year and develop each project within two years time as the German Renewable Energy Act offers a bonus for projects commissioning before the end of 2015 and decreases its tariff and bonus by 1/100 each year (see also Table 2).

The investment volume for each project was projected to approx. 45 Mio. USD including the reservoir development and the erection of the plant. The equity for the first investment phase made up approximately 30 Mio. USD and was paid in by the partner according to their shares in the SPV.

3.1 Key Figures

The southern German Molasse basin had been determined as region of the first privately financed projects by the investors and developers. Its geology was regarded to be not as complex as in other regions and with regard to potential flow rates the most promising. The hydrothermal reservoirs in the Molasse are regularly developed as doublet, triplet or double-doublet with depths ranging from 3 km to 5 km (TVD). The two projects develop the reservoir with a doublet, i.e. one well for the extraction and one well for the re-injection of the thermal water. The first project – Dürrnhaar – started at the end of 2007 and the second – Kirchstockach – commenced mid 2008. For both projects well head temperatures of 135°C (275°F) had been projected with flow rates significantly exceeding 100 l/s so that a binary cycle power plant can generate an electrical output of approximately 5.000 kW.

During the drilling of the second well of the first project serious problems, such as mud loss, lost-in-hole incidents and casing collapse occurred at the end of 2008. This led to time delays and a severe cost increase.

However, pumping test delivered encouraging result for the proof of productivity. In comparison to the first project the second one indicates a more advantageous trend in costs and time. Although the projected frequency of two projects each year could not be adhered to it remains the target of the SPV.

Table 2: Details and comparison of the tariff and bonuses of the German Renewable Energy Act (EEG); [1)] Projects commissioning before the end of 2015 obtain the early bird bonus. [2)] The technology bonus is paid to projects applying new technologies, e.g. HDR. [3)] If a projects sales sufficient heat in terms of the act amendment it gets the heat bonus.

		EEG 2006	EEG 2009
Basis tariff	EUR/kWh	0,15	0,16
Early bird bonus [1)]	EUR/kWh	---	0,04
Technology bonus [2)]	EUR/kWh	---	0,03
Heat bonus [3)]	EUR/kWh	---	0,03
Remuneration period	years	20	20
Degression per year	[-]	0,01	0,01

Table 3: Details for the Dürrnhaar and Kirchstockach geothermal project (ref. date 06/2009)

		Dürrnhaar	Kirchstockach
Development concept		Doublet (Gt1+Gt2)	Doublet (Gt1+Gt2)
Drilling sites		1	1
Drilling types		Directional drilling	Directional drilling
Casing diameter		18 5/8 ´´ - 7´´	18 5/8 ´´ - 7´´
Gt1	**Depth MD**	**4.393 m**	**4.214 m**
	Start	11/2007	09/2008
	End	04/2008	12/2008
	Pumping test	04/2008	07/2009
Gt2	**Depth MD**	**4.530 m**	**4.180 m**
	Start	04/2008	07/2009
	End	02/2009	11/2009
	Pumping test	02/2009	11/2009
Circulation test		04/2009 - 06/2009	12/2010-01/2011

Figure 1: On the left: Drilling Site of the Kirchstockach project with the geothermal drilling rig; on the right: Head of the Gt1 well of the Dürrnhaar project

Resource development	Plant erection	Plant operation
Highly fraught with risks Insurance coverage limited No external finance High contingencies required	Proven plants - limited risk Insurance services available External finance accessible Low contingencies required	
1. Investment Phase	**2. Investment Phase**	**Operation Phase**

Figure 2: Project structure with division into the first and second investment phase and an operation phase, the phases are divided by the proof of productivity and the commissioning of the plant

Table 4: Structure of the financing approach for the first and second investment phases

	Resource development	Plant erection	Plant operation
Phase	**1. Investment Phase**	**2. Investment Phase**	**Operation Phase**
Type of financing	Corporate Financing	Project Financing	
Equity capital	100 %	20-30 %	
External capital	0 %	80-70 %	

Table 5: Possible scenarios to realize the projects with varying commitment of the investor

	Resource development	Plant erection	Plant operation
Scenario 1	investor	investor	investor
Scenario 2	investor	investor	external
Scenario 3	investor	external	external

3. 2 Project Structure and Financing

The analysis of geothermal power projects with regard to their risk structure underlined that the most severe risks are associated with the reservoir development phase of these projects. Once the target horizon has been developed and proven to be sufficiently productive, the power plant construction and facility operation are limited-risk tasks in comparison to the subsurface activities.

Due to this risk distribution the two presented projects were divided into two different investment phases and the subsequent operation phase. The first phase comprised all efforts until the productivity of the reservoir had been confirmed. The risks of the first phase (geology, drilling, productivity, technology) were to be borne prevalently by the project developer or investor. The second investment phase covered the erection of the power plant and its commissioning. Assuming the application of a proven power generation technology the risks were limited and controllable. The same applies for the subsequent period of plant operation. Figure 2 indicates this structure.

Generally there are different options for the investor to handle risks. One of those options, an insurance coverage for the geological, drilling and productivity risk, was and still is difficult to obtain and associated with high premiums. This is due to fact that the petroleum industry is a self-insurer and only a limited number of geothermal projects have been implemented in Germany so far leading to a limited statistical basis for insurance companies. Consequently, instead of insuring those risks the saved insurance premiums were added to the project budget as contingency. This reflects the idea of self-insurance.

Furthermore the approach of distributing the risks over a series of projects (portfolio effect) was established. One failing project can be handled when other projects of the series are implemented successfully.

As the drilling of the doublets bears by far the highest risk with regard to costs and time it was essential from the corporate investor’s point of view that an experienced in-house drilling contractor was at hand to perform these drilling activities during the first investment phase.

Moreover, the identified risk was met with appropriate professional excellence on part of the developer and investor. This ensured best control and reactions in case of unforeseen incidents, e.g. during drilling, and therefore is a core element in handling projects´ risks.

Evolving from the risk analysis and the project structure, the financing was set up. Due to the market situation the first investment phase usually had to be financed by 100% equity. This was mainly caused by the above outlined characteristic of the projects´ risks. The availability of funds (equity and loans) became worse with the scarcity of investment capital during the financial crises of 2008/09. The German government set up special support programs for geothermal projects through its KfW Bankengruppe (bank for reconstruction). However, it still has to be proven, that these programs will add sufficient stimulus for lenders to fund geothermal power projects. For the second phase project financing with an approximate gearing of 30/70 was available as Table 4 shows.

Having split the project into two distinctive investment phases and the following phase of operation, a structure was given that enables the investor to flexibly determine his commitment within the project, i.e. being able to offer the project at various stages to the secondary market for purchase. As the initial equity amount is significant the investor can sell the project after the first investment phase and regain its capital. With a progressing implementation of projects this model, however, allows the investor to either sell the project after the resource development and commissioning or even operate the plant itself as

Table 5 states.

For the first project it was decided to offer the doublet to the secondary market after productivity has been proven mid 2009 according to scenario 3 in

Table 5. In that way capital could be returned and invested into subsequent projects. In addition to the productive doublet a general contract for the power plant erection, commissioning and operation had been offered to the external. It is planned to sell the Kirchstockach project as well. However, in the long-term perspective the erection of power plants and their operation are intended to be realized by the project company itself.

To evaluate potential projects in regard to their profitability only legally guaranteed revenues from the German Renewable Energy Act had been taken into account. Costs (CAPEX and OPEX) had been estimated conservatively. Additional buffer budgets were included to account for e.g. additional material during drilling, delays or extra stimulation efforts.

Depending on the location of the project and its spatial development an additional sale of heat or cold might become possible in the project´s life time so that it generates upsides in its revenues and thus improves its efficiency.

During its first projects the SPV went through a manifold learning curve. Experiences had been gained throughout all project stages. The set up of projects, the permitting process, the reservoir development including the drilling works and the design of the above surface facilities are only a few issues the company made worthwhile – even though expensive – experiences with.

The process of selling the first productive doublet to the secondary market, however, indicated that the assumptions concerning the prosperity of such projects were made correctly and renders geothermal power projects in the Molasse economical viable.

4. CONCLUSION

Geothermal energy projects as a new market expose project developers and investors to new challenges as they come up with considerable risks. However, these projects embody valuable chances that can compensate for the risks. The first projects financed by corporate equity verify the assumption of profitability, risks and challenges and underline the necessity for sound risk management strategies and financial strength of the projects´ investors. Most important, however, it is to conclude that with the amendment of the EEG an instrument was formed to render geothermal power projects – at least in the Molasse basin –economical viable for corporate investor.