Geothermal District Heating in Europe

Models for banks and financial institutions

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District Heating systems in Hungary (left) and Copenhagen (Right)

About the GeoDH Project

In Europe, there are over 5,000 district heating systems, including 237 GeoDH systems, and the market share of district heat is about 10% of the heating market. The crucial challenge is to promote geothermal district heating in Europe and to facilitate its penetration to the market.

There are several Eastern and Central European countries, such as Hungary, Poland, Slovakia, Slovenia, Czech Republic, Bulgaria, and Romania with geothermal DH systems installed. However, the potential is much larger. In the other Eastern and Central Europe countries - Bulgaria, Czech Republic, Slovenia, there is both the need to convince decision makers and to adopt the right regulatory framework but also to establish the market conditions for a development of the GeoDH market.

Several Western European countries have 2020 targets for geothermal DH of which Germany, France and Italy are the most ambitious. In order to reach these targets, simplification of procedures is needed and more financing required.

A third group of EU countries includes those Member States currently developing their first geothermal DH systems, such as the Netherlands, UK, Ireland and Denmark. There is no tradition of GeoDH so there is a need to establish the market conditions for its development.

The GeoDH consortium has been working on these 3 different groups of countries, thus with juvenile, in transition and mature markets, in 14 countries in total, in order to achieve results replicable across the EU28.

Objectives of GeoDH

Today geothermal DH technology is poorly developed although the potential of deep geothermal is significant. Subsequently, the specific objectives of GeoDH are to:

- Propose the removal of regulatory barriers in order to promote the best circumstances and to simplify the procedures for operators and policy makers.
- Develop innovative financial models for GeoDH in order to overcome the current financial crisis which is hampering the financing of geothermal projects which are capital intensive.
- Train technicians and decision-makers of regional and local authorities in order to provide the technical background necessary to approve and support projects.

Introduction

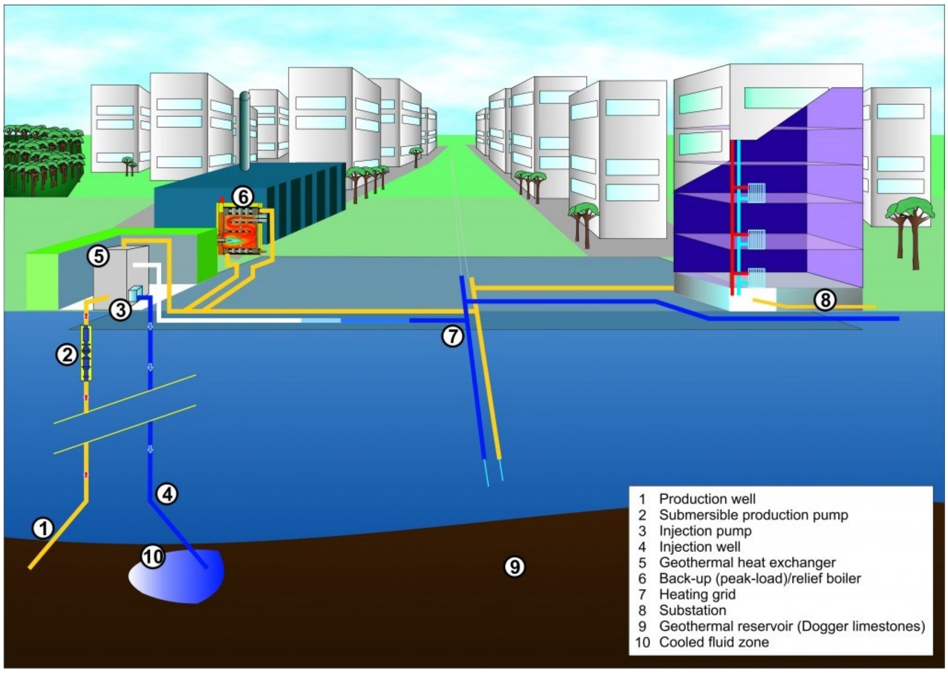
District heating – DH – is a system which distributes heat from a centralised generation plant to end users (residential, tertiary, commercial, recreational facilities…), connected via a heating grid and substations.
DH has replaced, in most instances, traditional central heating systems where each building is heated by an individual boiler. Clearly, DH achieves higher energy, economic and environmental performance. Heat supply is best adjusted to users demand. Individual building boilers are replaced by a heat exchanger three way valve piping outfit, fuel supplies and operation/maintenance are optimised, all factors resulting in significant savings. Last but not least, it reduces greenhouse gas emissions and excess heat losses, thus securing upgraded environmental control. As of early 2000's European DH market penetration stands as follows (percentage of district heated houses): Iceland: 96%; Baltic States / Poland / Sweden / Denmark / Finland: 50-60%; Austria / Germany: 12-15%; France 6%; UK/Netherlands: 1-4%; This record reflects the fact that Iceland enjoys abundant geothermal resources added to a consistent energy policy of the state in favour of energy savings and renewable energy sources. Despite its "modernity" DH is nothing new. As a matter of fact, it dates back to Roman ages as witnessed by remnants evidencing city homes and baths heated via natural hot water catchments and piping. At Chaudes-Aigues, in Central France, a city DH system, pioneered in year 1330, fed by the Par hot spring at 82°C, is still operating to date. Heated homes were charged, in those times, a tax by the local landlord in exchange of maintenance duties, as reported in the city annals. It is obvious that these early DH systems could be completed thanks to local hot springs and shallow wells, i.e. (sub) surface evidence of geothermal heat conveyed by water. The possibility to drill deep wells since the 1900's allow to produce hot water digging to deep reservoirs from 500 to 3000m and using technologies inspired from oil and gas exploration.

Geothermal District Heating (GeoDH) is the use of geothermal energy (i.e. the energy stored in form of heat below the earth's surface) to heat individual and commercial buildings, as well as for industry, through a distribution network.

The first regions to install GeoDH, were those with the best hydrothermal potential, however with new technologies and systems, there is an ever increasing batch of regions that are developing geothermal technology for heating & cooling. Systems can be small (from 0.5 to 2 MWth) and larger with capacity of 50 MWth. Some new district heating schemes that utilize shallow geothermal resources, assisted by large heat pumps. The 'hot' GeoDH markets in Europe are in France (Paris, and renewed activity in the Aquitaine basin), Germany (Munich), Hungary and more recently The Netherlands with more than 30 doublets underway, but it is important to always underline that geothermal DH systems can be installed in all European countries. The following map gives an indication of what are the good resources zones (in green) where existing GeoDh are in red.

MAIN TECHNOLOGIES AND USES

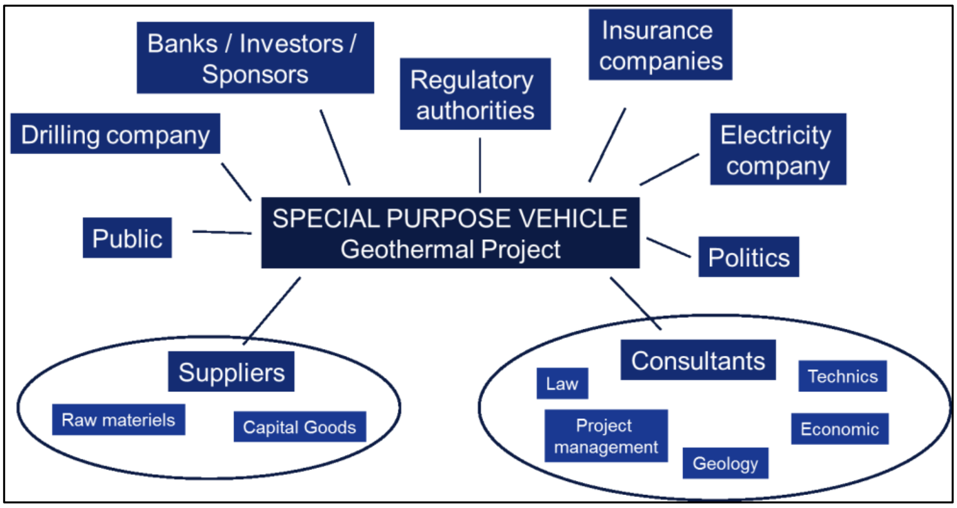
Many GeoDH systems (such as in the Paris Basin) are based on a dependable sedimentary resource environment, and on the doublet concept of heat extraction. Modern doublet designs include two wells drilled in deviation from a single drilling pad. Bottom hole spacing's are designed to secure a minimum twenty year span, before cooling of the production well occurs. Well depths (deviated) of 2,000m to 3,500m are not uncommon; and these are often located in sensitive, densely populated urban environments, therefore requiring heavy duty, silent rigs (up to 350 tons hook loads, diesel electric drive).



As is the case in Milan, we are also seeing the installation for systems with lower temperature assisted by heat pumps. In several instances (Denmark, Germany, Iceland) absorption heat pumps, often associated with geothermal Combined Heat & Power plants (CHP), have been successfully installed and operated. Additionally, the installation of GeoDH systems becomes more economic close to areas with higher urban density, as both resources and demand need to be geographically matched. One considerable challenge in the current economic crisis concerns the financing and the development of new heat grid infrastructures. Retrofitting is an alternative for developing the GeoDH market. Oradea, in Western Romania, is an example of the insertion of a geothermal heating system into the existing city: a coal fired/back pressure system, combined heat and power (CHP) network, typical of previous Central/Eastern Europe district heating practice. Geothermal district cooling is actually poorly developed in Europe, with merely 30 MWth installed cold power. This development issue should be challenged by geothermal operators (and users), as it could provide additional summer loads to GeoDH systems. The following map shows the areas were geothermal resources are available in Europe and the red points shows the cities where GeoDH are already in exploitation.

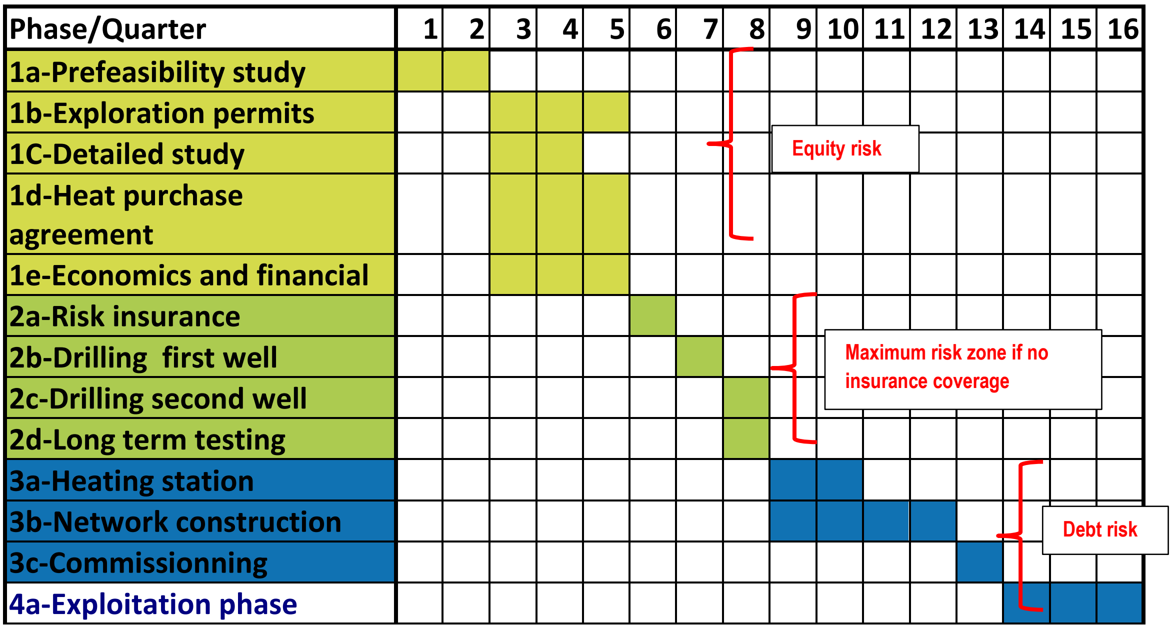
Project team and interplay between disciplines

A number of different players are involved in a geothermal project over several years of project and implementation. The project manager or developer plays a key role for the success of a project, especially in the early stages. He has to comply with the complex requirements related to structuring, developing and risk mitigation.
A team of consultants is needed to assist the project team and it is necessary to merge an enormous variety of skills, abilities and experiences. This team which includes financial experts, legal and technical expert, e.g. geochemists, reservoir engineers, drilling specialists, heat power generation and distribution engineers, environmental experts, must be established. The challenge of the manager/developer is to keep the complexity of the project under control especially regarding cash flow course.



The phases of a GeoDH project at a glance

If the project is located in a favourable zone already drilled and where the geological and hydrogeological conditions are known, the risk is considered as small and can be covered by a private insurance system. The insurance assuming that the third part expert doing due diligence for the insurance company does accept the conclusions of the specialized engineering company paid by the promoter or developer of the geothermal plant. If not the promoter has to drill the well at its own risk except in countries where a mutualistic insurance system is in place as in France, Germany and The Netherland. When the project is located in areas where no deep wells has been drilled for water, mine or oil and gas exploration, the geological risk is maximum and without an exploration well carried out by a State geological survey appears to limit drastically the development of a geothermal plant.



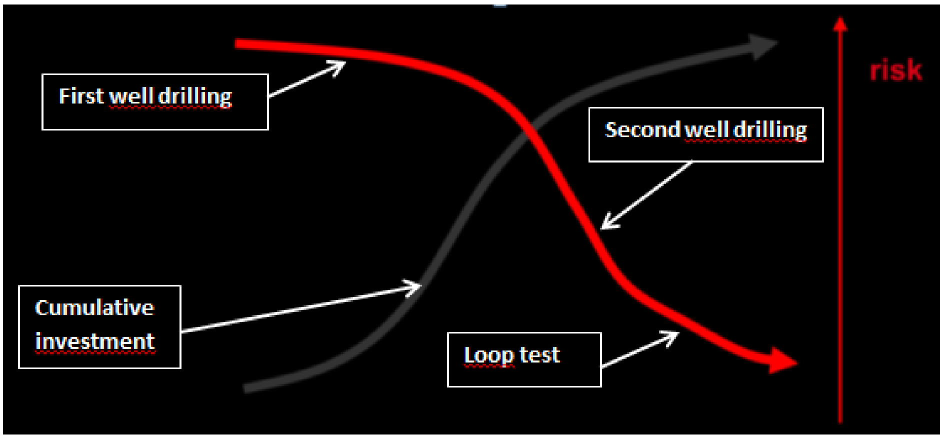
This planning shows that the normal duration to build a new GeoDH system is of about more than three years which is two times less compared to a geothermal plant for electricity generation. The risky zone is the second one (in yellow). The minimum power of the plant to be operated is to cover a significant percentage of the total heating/cooling needs of the network. The sensitive ratio remains the ratio temperature/flow rate which indicates the power of the first well. Usually the temperature even of paramount importance is relatively well known; on the contrary the quantity of hot water that can be produced from the geothermal reservoir at a commercial level is much more uncertain. The main geothermal risk is the permeability of the reservoir and this parameter needs a drilling hole at real scale to be measured and validated.

The risk is decreasing following the red curve, its decrease drastically after the positive result of the first well but remain even small during the operation period of the plant which can be as much as 45-50 years.

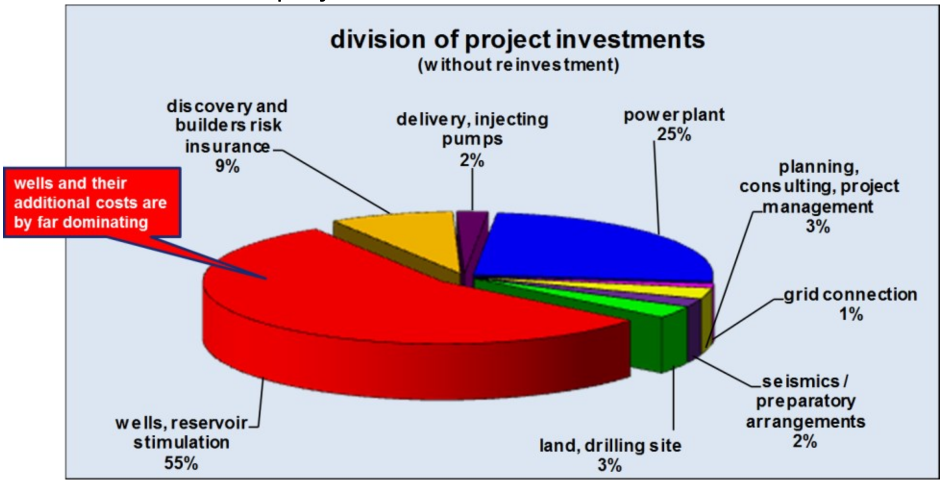
Risk management

A geothermal district heating is based on the estimated thermal power that could be generated at the surface using or not pumping systems. The power is the multiplication of the difference between the water temperatures at the well head of the production well and the lower temperature at the reinjection well multiplied by the flow rate. Usually in well-known zones which are suitable for GeoDH because existing documented wells, in general not geothermal but often coming from unsuccessful previous mining or oil and gas exploration wells, the temperature is a parameter with a very small risk. On the contrary the productivity of the geothermal reservoir (capability to produce a big flow rate of 100 to 300 m^3/h) is impossible to predict with a sufficient accuracy to drill without risk.

The risky zone 2 b-c-d mentioned in the above planning (in yellow) is decreasing with the following curve.



The cost of a GeoDH project can be ventilated as follow:



Two scenarios are possible with existing DH to be adapted or to be created:

- Cogeneration of electricity and heat if the geothermal water temperature is from 150°C to 80°C
- Heat production from 150°C to 45°C if the network is a very low temperature district heating scheme feeding only floor panels

A geothermal DH project is based on the estimated geothermal heat that can be generated from the reservoir and the estimation of costs and revenue streams related to each individual project. Estimating prospective costs and revenue streams involves uncertainties and risks.
Financial backers are sensitive to project risks especially because of the Basel-II-principles and the lack of knowledge about geothermal projects. Therefore, solid project planning and risk management are essential elements of a developing project, and need to be implemented at the earliest stage.
Risk management does not necessarily imply the elimination of risks, but rather their systematic management and mitigation. Risks have to be identified and evaluated in terms

of their probability and the (economic) consequences of their occurrence. Once these assessments have been made, strategies for risk management need to be developed. Sometimes, it will not be possible to avoid risks by means of appropriate and "affordable" measures. Often, risk reduction is satisfactory. Some risks may be passed on to third parties, for example through insurance. Three kinds of insurance systems has to be taken into account for each project:

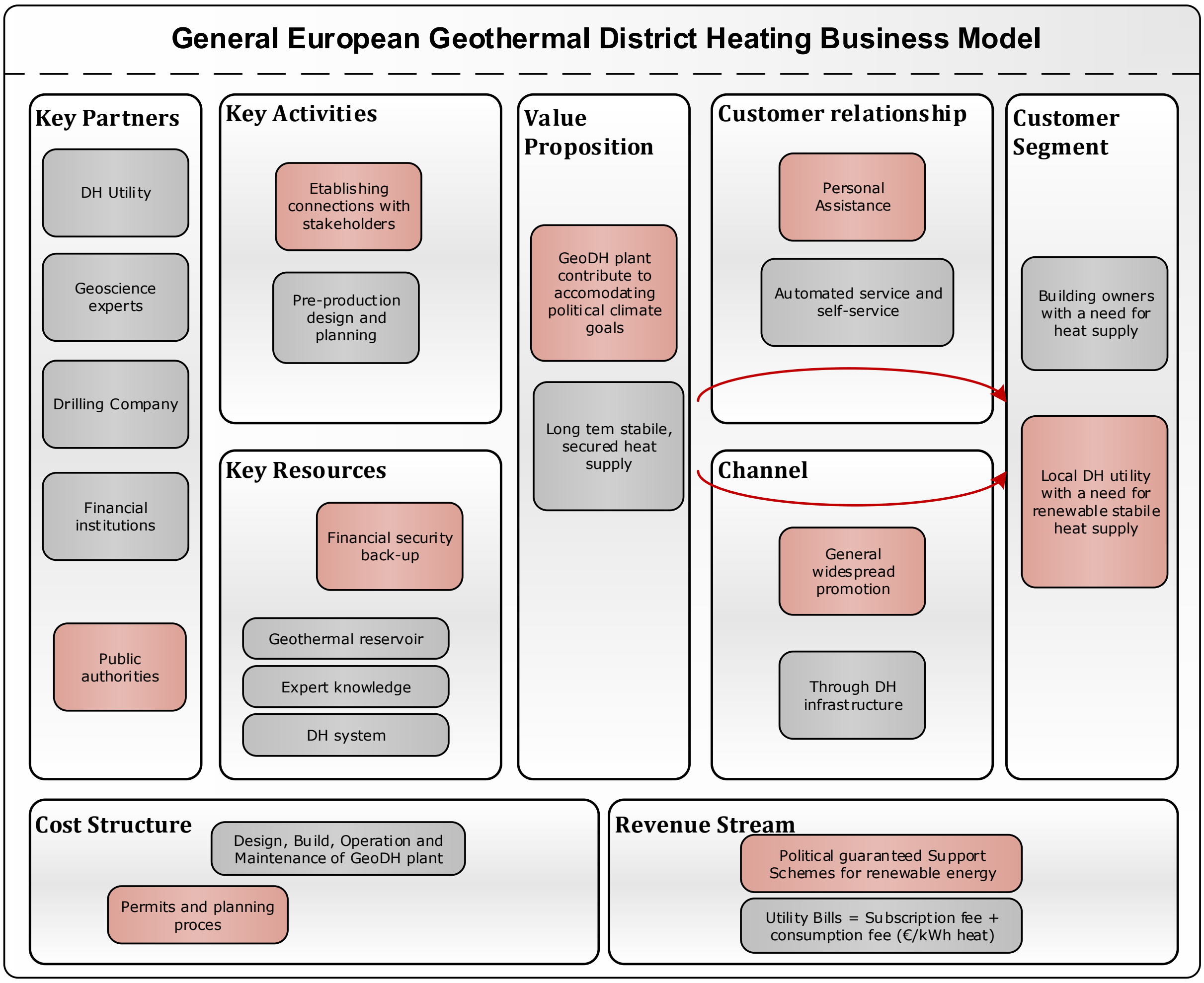
- Business liability insurance
- Construction all risk insurance which is related to all the possible damages due to a failure in the technical realization of the deep wells such as lost in hole equipment, side tracks if the deviation is not correct, cementing problems...
- Mining risk which is related to the discovery of a suitable thermal capacity and flow-rate of the geothermal reservoir

A GeoDH project cannot be developed without contracting risk insurance, the two first, listed above, are common and many companies are offering this type of contract. The coverage of mining risk is more difficult in many countries which have not put in place a system at national level. The private sector is offering this type of insurance with a lot of restriction and premium up to 20% of the well costs, additionally the insurance deductible could be of very high level (up to 10% of the investment to be covered).

Lastly, there are risks that the company will categorise as (financially) acceptable and cover with equity capital directly.
Most of the investment falls into the high-risk phase of the geothermal project. While the project is being developed, the required budget changes successively. And with increasing effort in exploration, more and more knowledge about the resource is acquired and the risk of failure decreases accordingly. Finally, beyond exploration, the bankability of a geothermal project is threatened by the geological risk.
Risk insurance funds for the geological risk already exist in some European countries (France, Germany, Iceland, The Netherlands and Switzerland). The geological risk is a common issue all over Europe. Collaboration between Member States is desirable; it can allow them to save money and trigger the uptake of a valuable technology alike.

For this reason the GeoDH project following the Geoelec project can confirm the dramatic necessity to create a Geothermal Risk Insurance Fund at the EU level, this fund is of the utmost importance for the deep geothermal sector in Europe to develop zones in which no geothermal plants do exist at the moment even favourable geological and hydrogeological conditions. (See annex 1- EGRIF).

The business model has been established and to additional boxes has been created in the following diagram: the risk insurance included in the key partners listing and the HPA included in the customer segment.



HPA (heat purchase agreement). Before to engage the phase 2 with drilling of the first well designed to be the exploitation (production or reinjection) well in a diameter sufficient to have the maximum flow-rate, the first step is to negotiate a contract to sell the heat and cold to the customer. There are two different cases:

- If the district heating network do exist and even some technical modification are needed on the network itself or in the heating stations and substations. In that case, the client to buy energy is clearly identified (public or private or a mix) and a pre-contract has to be negotiated in order to sign a minimum agreement to purchase a certain amount of heat per year during a sufficiently long period, usually comprised between 15 up to 30, in order to secure the reimbursement of the bank loan, depending the laws in force in the country.

- If the district heating network is to be built, the same type of agreement has to be signed and if several customers, a separate contract has to be negociated with guarantees of quantity, price and duration of the heat sales contract.

  This step is of paramount importance and many projects cannot find any banking support if this type of HPA is not provided to the bank, before to begin the negotiation and after covering the
  geothermal risk.

GO / NOGO road of a geothermal district heating plant construction

The following steps have to be engaged:

1) Pre-feasibility study which includes:

A - Pre-Sales: Project pre-design, MOU for heat purchase agreement with customers and financing research
B - Preliminary survey
C - Prefeasibility study (surface and sub-surface)

⇨ **GO / NOGO**
Geothermal expected potential confirmed and existing customers ready to buy heat at a fixed cost for a long duration which has to exceed the loan period

2) Exploration and feasibility study which includes:

A - Detailed studies, including geophysics if possible and permiting to obtain the rigtht to drill a doublet system
B - Negociation to get a coverage for the first and second well + geothermal loop testing
C - Project economical review and financing strategy

⇨ **GO / NOGO**
Confirmation of geothermal potential (depth, temperature, flow-rate), insurance coverage secured and financial details arranged

3) Drilling of wells which includes

A – Drilling of first well (preferably vertical)

⇨ **GO / NOGO**
The project is stopped if the result of the first well is under a ratio temperature/flow-rate under the limits of the success curve built and annexed in the insurance contract

B - Drilling of the second well and loop test

⇨ **GO / NOGO**
The project could be stopped at that time if the capacity of the second well is much lower or do not accept to reinject the totality of the flow rate

4) District heating construction which includes:

A - Equipment of the geothermal loop (submersible pump, surface injection pumps, electrical variators, heat exchanger installation, chemical treatment if any), monitoring of the loop and testing
B - Construction of the piping network or adaptation of the existing network
C - Construction of the heating station (the closest possible from the drilling pad) or adaptation of the existing

5) Commissioning of the whole installation which includes:

A - First year of operation with detailed measurements on the geothermal loop (levels in the wells,well-head pressure, physico-chemistry of the water, pumps electrical consumption etc…)
B - First year of operation with detailed measurements on the DH network (temperature, flow –rate, return temperature to the exchanger, follow up of back up boilers and calculations of energy balance with the coverage of geothermal
C - Normal exploitation of the plant including well controls, repairs and heavy maintenance and equipment replacement.