Presented at "Short Course on Surface Exploration for Geothermal Resources",
organized by UNU-GTP and LaGeo, in Ahuachapan and Santa Tecla, El Salvador, 17-30 October, 2009.

UNITED NATIONS UNIVERSITY
GEOTHERMAL TRAINING PROGRAMME

LaGeo S.A. de C.V.

PLANNING OF GEOTHERMAL PROJECTS: A CASE STUDY ON CENTRAL AMERICA

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ABSTRACT

Planning plays an important role for the development of geothermal resources and must be carefully performed from the beginning and through the entire period of the project. The PMI approach seems to be useful and perhaps it must be applied as a norm, but due to the high level of uncertainties and risks, it is required to be divided it into stages. The initial level of risk in a green field is 100% (nobody knows anything), but this must be reduced to 20-40% during the commercial exploitation for it to be developed profitably.

A geothermal project with a 30 MW condensing type power capacity could require 7 to 12 years of development and 65-80 M$ of capital investment. Usually, permits concession grants, looking for financial support and making decisions are some of the factors that are time-consuming in the development of the energy resource, hence delaying some of activities associated with the project.

1. INTRODUCTION

According to the Project Management Institute (PMI), project management is a carefully planned and organized effort to accomplish a specific (and usually) one-time objective, for example, to construct a building or implement a new major computer system. It includes developing a project plan, which involves defining and confirming the project goals and objectives, identifying tasks and how goals will be achieved, quantifying the resources needed, and determining budgets and timelines for completion.

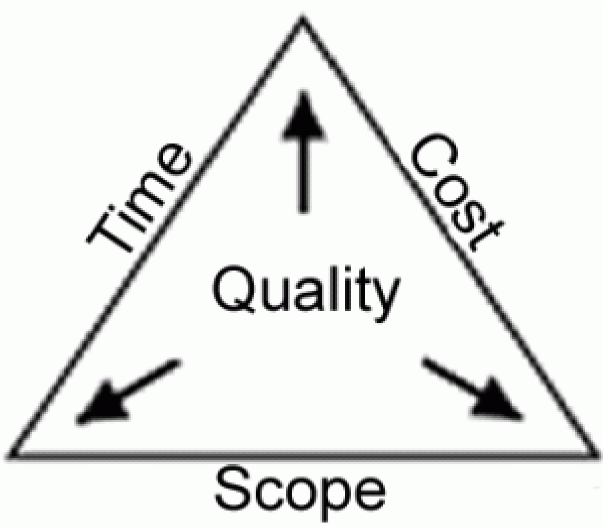

FIGURE 1: Triangle of the projects

It also includes managing the implementation of the project plan, along with operating regular controls to ensure that there is accurate and objective information on the performance relative to the plan, and the mechanisms to implement recovery actions where necessary. Projects usually follow major phases or stages, including feasibility, definition, project planning, implementation, evaluation and support/maintenance. As shown in Figure 1, there are three important constraints for all projects:

time, which always plays an important role; the cost; and finally the scope. The best way to do a project is to have a good equilibrium between these aspects in order to achieve the best quality.

2. THE SPECIFICATION

A specification is the definition of the project; a statement of the problem, not the solution. Normally, it contains errors, ambiguities, misunderstandings and problems among the entire team. Thus, before venturing on the next six months of activity, it must be evaluated so that the team will not be working on the wrong project. The outcome should be a *written* definition of what is required or the period of execution; and this must be *agreed* by all the ones involved. There are no short-cuts to this; if one fails to spend the time initially, it will cost him more later on.

The work on the specification can be seen as the first stage of Quality Assurance since one is looking for and encountering problems at the very start of the project - from this perspective, the creation of the specification clearly merits a large investment of time.

This seems to be a long document, but it is not. Each of the above could be a simple sub-heading followed by either bullet points or a table – and it is not like writing a brochure, simply stating the definition of the project in clear, concise and unambiguous way.

3. PROVIDING THE STRUCTURE

Having decided what the specification intends, the next problem is to decide what the team actually needs to do, and how to do it. The manager has to provide some form of framework both to plan and to communicate what needs to be done. Without a structure, the work is a series of unrelated tasks which provides little sense of achievement and no feeling of advancement. If the team has no grasp of how individual tasks fit together towards an understood goal, then the work will seem pointless and they will feel only frustration.

To take the planning forward, therefore, one needs to turn the specification into a complete set of tasks with a linked structure. Fortunately, these two requirements are met at the same time since the derivation of such a structure is the simplest method of coming to a list of tasks.

3.1 Work breakdown structure

Once you have a clear understanding of the project, one then describes it as a set of simpler separate *activities*. If any of these are still too complex, one can break them down also into another level of simpler descriptions, and so on until one can manage everything. Thus, the complex project is organized as a set of simple tasks which when combined can achieve the desired result. The reason behind this is that the human brain can only take in and process a limited amount of information at a time. To get a real grasp of the project, one has to think about it in parts rather than by trying to process all the details at once. Thus, each level of the project can be understood as the consolidation of simpler, smaller units.

In planning any project, there are the same, simple steps to follow: if an item is too complicated to manage, it should be converted into a list of simpler items, sometimes known as the *breakdown of work structure* to make it sound more formal and impressive. Without following this formal approach, one sometimes forgets the small details; and with this procedure, the details are simply displayed on the final lists. One common fault is to include too many details in the initial planning stage. One should stop when the description of the activity is sufficient to provide clear instructions for the person who will actually do the work, and to have a reasonable estimate for the total time/effort involved. There should be somebody to allocate (or delegate) the task; another to finish the planning.

3.2 Task allocation

The next stage is a little more complicated as one needs to allocate the tasks to different people in the team and, at the same time, arrange these tasks so that they are performed in a sensible sequence.
Task allocation is not simply a case of handing out the various tasks on the final lists to the people that are available; it is far more subtle (and powerful) than that. The manager has to look far beyond the project; indeed any individual project can be seen as merely a single step in the team's development. The allocation of tasks should thus be seen as a means of increasing the skills and experience of the team. When the project is done, the team should have gained more experience.

In simple terms, consider what each member of the team is capable of and allocate a sufficient complexity of tasks to match their capability. The tasks you allocate are *not* the ones on your final lists, they are adapted to better suit the needs of the team's development. *Tasks are moulded to fit people*, which is far more effective than doing it the other way around. Sometimes they can be grouped and allocated together. For instance, some tasks which are seemingly independent may benefit from being done together since they use common ideas, information, and talents. A single person doing both jobs removes the start-up time for one of them; two people (one on each task) might be able to help each other.

3.3 Guesstimating

At the initial planning stage, the main objective is to get a *realistic* estimate of the time involved in the project. One must establish this not only to assist higher management with their planning, but also to protect the team from being expected to do the impossible. The most important technique for achieving this is known as: *guesstimating*. Guesstimating schedules is notoriously difficult but it is guided by two approaches:

- Make the guesstimates of the simple tasks at the bottom of the breakdown of the work structure and look for the longest path through the sequence diagram;
- Use experience from previous projects to improve the guesstimating skills.

The corollary to this is that one should keep records in an easily accessible form of all projects. Part of the final project review should be to update the personal database of the length of time of the activities. Managing this planning phase is vital to success as a manager. Some people find guesstimating a difficult concept in that if one has no experience in an activity there will be no worthwhile estimate. The point is that from very little experience of the given problem, one can actually come up with a working estimate and one which is far better than no estimate at all when it comes to deriving a schedule. Guesstimating does take a little practice, but it is a very useful skill to develop.

There are two practical problems in guesstimating. First, one can become too optimistic. It is human nature to ignore the difficulties and assume the best case scenario at the beginning of a new project; in producing the estimates (and using other information) one must be a little realistic. In practice, one should also build in a little slack to allow for some tolerance towards mistakes. This is known as *defensive scheduling*. Also, if one eventually delivers ahead of the agreed schedule, one will be appreciated.

Second, one will be under pressure from senior management to provide the estimates as fast as possible, especially if the project is being presented competitively. One should resist the temptation to rely upon speed as the only selling point. One can, for instance, suggest the criteria of fewer errors, history of compliance to initial schedules, previous customer satisfaction, "this is how long it takes, so how can you trust the other quotes".

4. ESTABLISHING CONTROLS

When the planning phase is over (and agreed upon), the execution phase begins. Once it is in progress, a project acquires a direction and momentum which is totally independent of anything predicted. If one comes to terms with that from the start, one can then handle the ups and downs that follow. One needs to establish from the start (within the plan) the means to monitor and to influence the project's progress. There are two key elements to the control of a project:

- Milestones (clear, unambiguous targets of what, and when); and
- Established means of communication.

Milestones are mechanisms to monitor progress; for the team, they are short-term goals which are far more tangible than the uncertain completion of the entire project. They maintain the momentum and encourage effort; they allow the team to judge their own progress and to celebrate achievements throughout the project rather than just at its end.

The simplest way to construct milestones is to take the timing of information from the breakdown of the work structure and the sequence diagram. When one has guesstimated how long each sub-task will take and has unified them together, one can identify when each of these tasks will actually be completed. This is simple and effective; however, it lacks creativity.

A second method is to construct more significant milestones. These can be found by identifying stages in the development of a project which are recognizable as steps towards the final product. Sometimes these are simply the higher levels of the structure like the completion of a market-evaluation phase. Sometimes, they cross many parallel activities for instance, a prototype of the eventual product or a mock-up of the new brochure format.

Communication is everything: to monitor progress, to receive early warning of danger, to promote cooperation, to motivate through team involvement; all of these rely upon communication. Regular reports are invaluable - if one clearly defines what information is needed and teaching your team how to provide it in a rapidly accessible form. Often, these reports merely say "progressing according to schedule". One needs to insist that the team monitors its own progress with concrete, tangible, measurements and if this is done, the figures should be included in the report. However, the real value of this practice comes when progress is not according to schedule; then the communication system is worth all the effort invested in its planning.

5. PROJECT RISK MANAGEMENT

The principles of project risk management can be stated very simple. Any project organization is subject to risks. One which finds itself in a state of continuous crisis is not capable in managing risks properly. Failure to do so is characterized by an inability to decide what to do, when to do it, and whether enough work has been done. Risk management is a facet of quality, using basic techniques of analysis and measurement to ensure that risks are properly identified, classified and handled.

Risk management is the systematic process of managing an organization's risk exposure to achieve its objectives in a consistent manner considering the public interest, human safety, environmental factors and legal actions (law). It consists of planning, organizing, leading, coordinating, and controlling activities undertaken with the intention of providing an efficient pre-loss plan that minimizes the adverse impact of risk on the organization's resources, earnings and cash flows.

Another definition is that a risk is a combination of constraint and uncertainty. Everybody faces problems and uncertainty in executing the project. Hence, it can be minimized by eliminating constraints or by finding and reducing uncertainty.

Figure 2 plots uncertainty against constraint. The curved line indicates the *acceptable level of risk*, whatever that may be in each case. The risk may be reduced to an acceptable level by reducing either uncertainty or constraint, or both. In practice, few people have the opportunity to reduce constraint, so most focus on the reduction of uncertainty. It is also worth noting from the diagram that total elimination of risk is rarely achieved. Therefore, one has to consider how to manage the remaining risk most effectively.

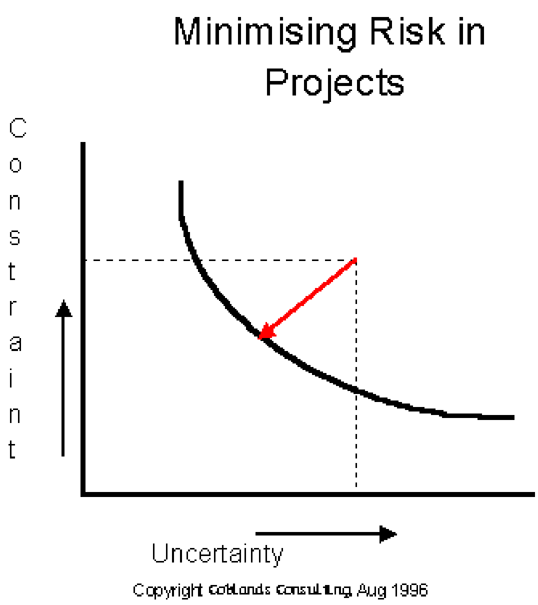

FIGURE 2: Minimizing risk in projects

There are two stages in the process of Project Risk Management: a) Risk Assessment and b) Risk Control. Risk Assessment can take place at any time during the project, though the sooner the better. However, Risk Control cannot be effective without a previous Risk Assessment. Similarly, most people tend to think that having performed a Risk Assessment, they have done all that is needed. Far too many projects spend a great deal of effort on Risk Assessment and then ignore Risk control completely.

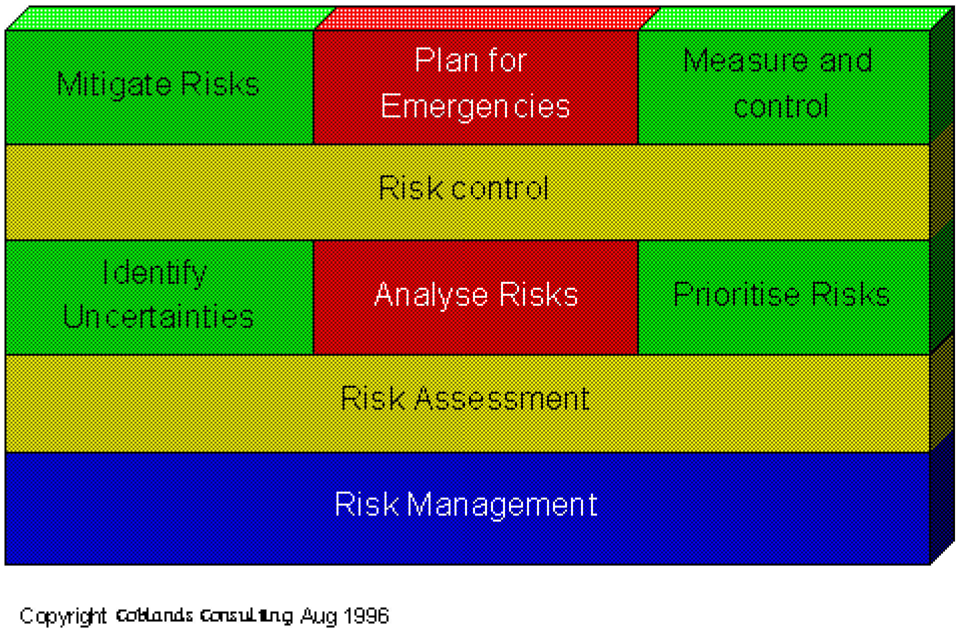

FIGURE 3: Risk Assessment management

As shown in Figure 3, the Risk Assessment has three elements:

a) Identify uncertainties
Explore the entire project plans and look for areas of uncertainty.

b) Analyze risks
Specify how those areas of uncertainty can impact the performance of the project, either in duration, cost or meeting the users' requirements.

c) Prioritize risks
Establish which of these risks should be eliminated completely, because of the potential extreme impact; which should have regular management attention; and which are sufficiently minor to avoid detailed management attention.

In the same way, Risk Control has three elements, shown as follows:

a) Mitigate risks
Take whatever actions are possible in advance to reduce the effect of risk. It is better to spend money on mitigation than to include contingency in the plan.

b) Plan for emergencies
For all those risks which are significant, have an emergency plan in place before they happen.

c) Measure and control.
Find the effects of the risks identified and handle them to get a successful conclusion.

6. GEOTHERMAL PROJECTS

In the geothermal industries, the approach to planning geothermal is slightly different than projects described above. It consists normally of three stages: Pre-feasibility, Feasibility, Construction and Commercial development, every stage with its own level of risk and cost.

During the feasibility stage, there is only superficial exploration covering broad and diverse areas (20-150 km^2), usually geological mapping, geochemical analysis, electrical DC or MT surveys, etc., in some countries 2-3 wells are included as deep exploration or exploratory drilling depending on the risk management and the financial funds available. The main goal of this stage is to determine if the reservoir exists and the reservoir temperature and also how permeable the system is.

The "Organizacion Latinoamericana de Energia" (OLADE, 1993) classifies geothermal projects in to several stages: a) reconnaissance which covers a very large area perhaps more than 1,000 km^2, b) prefeasibility which covers 400-500 km^2, c) feasibility with 10-100 km^2, and d) development and the commercial exploitation (Olade, 1993). The reconnaissance stage is used to establish the possibilities for geothermal resource development and to select a small area in which to do the prefeasibility. The prefeasibility results must indicate the location of the well sites through superficial exploration. If the exploration has been done successfully, the risk should be reduced. The results of the feasibility stage and specifically the drilling exploration will be to obtain the reservoir parameters (temperature, permeability, enthalpy, etc.), the resource assessment and the preliminary design of the energy utilization (power plant).

In the Central American countries, several practices have been undertaken; normally the government facilities companies (CEL, ICE, INDE, etc.) have been in charge of exploration, construction, development and operational activities. However, over the last 10 years, this has been changed due to BOP, BOT or share holder form to carry out the geothermal projects. In fact ICE (Costa Rica) is still undertaking projects under the government in decision making, timing and financing.

The geothermal projects carried out by the government have several differences with regards to privately owned companies, even if both follow the same project approach. Timing is perhaps the main difference because the government requires a long period of time to grant loans to perform the geothermal projects. Normally, these loans are granted by international development banks or cooperation agencies like IDB, BCIE, WB, AID, JICA, etc. If financing is given to prefeasibility or feasibility stages, the situation is quite difficult mainly due to the high risk involved and the relatively high cost for the exploratory drilling.

As an example, Las Pailas in Costa Rica has been waiting for more than 10 years for commercial development. The exploration for pre and feasibility stages were carried out in Las Pailas from 2000-2005 and the power plant operation is scheduled for 2011 (11 years). The Amatitlan field of Guatemala started the feasibility stage in 1989 and the 24 MW binary type power plant went on-line in 2007 (18 years).

For privately-owned companies, the scenario seems to be quite different. Funding is not necessarily a large constraint to developing geothermal projects, there are more problems in getting permits from environmental and regulatory authorities.

In El Salvador, LaGeo is developing several prefeasibility, feasibility and development projects which include deep drilling exploration. The main projects carried out during the last decade are the commissioning of Unit 3 of 44 MW in the Berlin field which includes 10 wells successfully drilled during a period of four years, the exploratory drilling of two wells at the Cuyanausul area, deep exploratory drilling of three wells in the San Vicente field and deep exploratory drilling of two wells in the Chinameca field (which is now under evaluation and testing).

The same situation is seen in Nicaragua where Geonica, a joint venture between ENEL and LaGeo, has been developing, since 2003, two geothermal fields: a) El Hoyo where one well has been drilled and b) Chiltepe with one gradient well drilled. Financial problems are perhaps the main constraints for other geothermal development in Nicaragua.

In Guatemala, ORMAT put on-line a new power plant at the Amatitlan site, and ENEL is going to drill the first exploratory well at the Tecuamburro site.

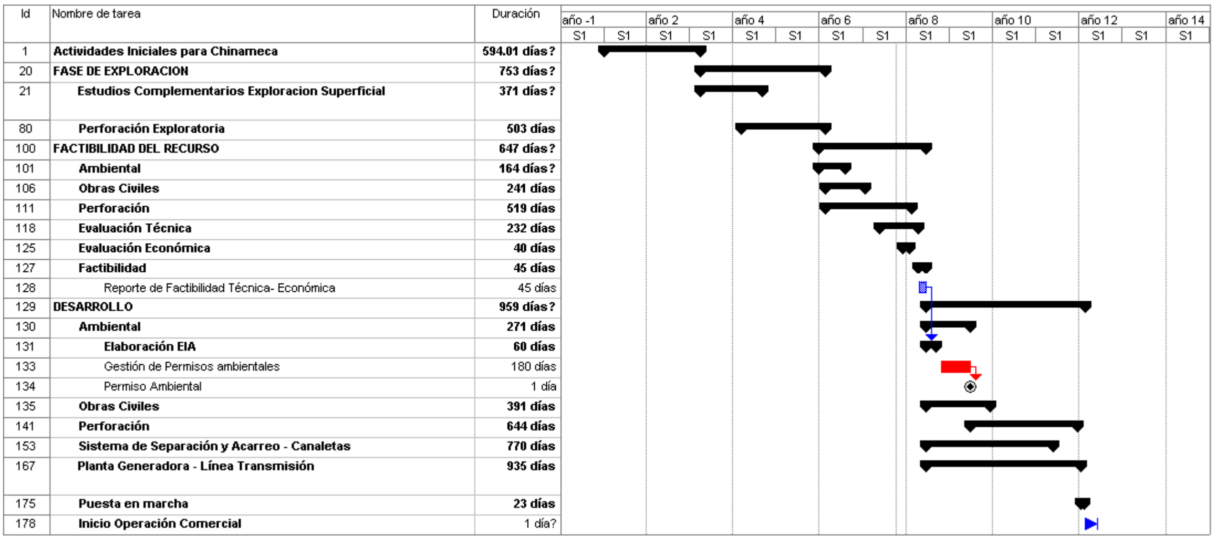

FIGURE 4: Chinameca project planning

Figure 4 shows the planning program for the Chinameca project. As mentioned earlier, perhaps the best way to develop geothermal projects is by dividing it into several stages; as separate projects, but with secure milestones for each one. The stages are surface exploration, exploratory drilling, feasibility, and development.

7. TIMING AND COST FOR GEOTHERMAL PROJECTS

To carry out the entire geothermal project, the cost and time estimation (guesstimating) shown in Table 1 could be used. In addition to Table 1, the time needed to get permits (environmental, communities, local authorities, etc.), is 1-2 years and 1-3 more years for concession processing.

In Table 1, the final cost of the whole geothermal project is in the range of 65-80 M$ to be developed over 5-7 years without permit and concession time, but on the other hand with permit and concession times, the period can be around 7-12 years.

TABLE 1: Time and cost estimation for geothermal projects*

Stage level	Cost (×1,000$)	Time (months)
Pre-feasibility, surface exploration, 10-50 km^2	100-500	6-10
Prefeasibility, 2 exploratory wells	5,000-10,000	12-18
Feasibility, surface exploration, resource assessment, 5 wells drilled	15,000-20,000	20-30
Construction 30 MW condensing power unit, 6 additional wells	45,000-50,000	30-36
Total	**65,100-80,500**	**68-94**

* Power plant capacity 30 MW, production 6 MW per well, steam consumption 2 kg/s/MW, dryness 20%, successful rate 70% and 50 kg/s injection capacity by gravity, no pumping use. Initial wells are included.

Figure 5 presents the requested investment for geothermal power projects in each stage and the risk involved. With the minimum risk observed in the region of 20-40%, this could mean that for every five wells drilled, at least one can fail.

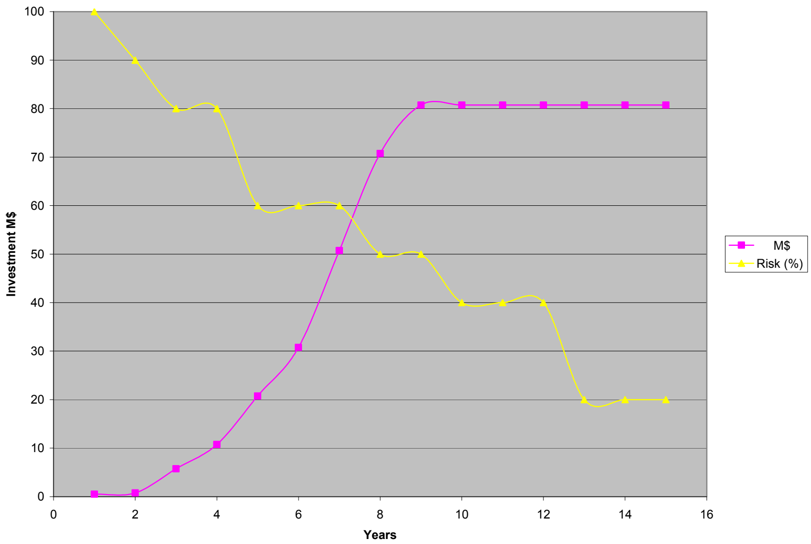

FIGURE 5: Investment versus risk for geothermal projects.

8. CONCLUSIONS

1. Planning is a powerful tool for the success of the geothermal projects and must be developed in stages. In spite of the difficulty to follow the standard approach of planning which has been established by PMI, it could be useful.
2. The stages for the whole geothermal project could be divided in small phases like: surface exploration (prefeasibility), drilling exploration (feasibility), development (production and injections wells, gathering system and power plant).
3. The total cost for a complete 30 MW condensing type geothermal project could be in the range of 65-80 M$ with a period of 5-12 years, depending on the permit and concession grant periods.
4. The risk management for geothermal projects could play an important role due to inherent resource risk; in fact the geothermal projects begin with 100% of risk and must decrease down to 20% as minimum. A higher risk ratio can involve a large amount of money to drill more wells.

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