GeoFund - IGA Geothermal Workshop "TURKEY 2009"
GEOTHERMAL ENERGY IN ECA REGION COUNTRIES
February 16-19, 2009 , Istanbul, Turkey

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BASICS OF DEVELOPING A GEOTHERMAL RESOURCE BASED POWER PRODUCTION PROJECT

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SUMMARY

This paper discusses the various stages that the developer needs to go through from initial thought to actual production of electricity. Each stage is outlined and presented in order to deliver initial idea of the various aspects of Geothermal Power Production Project (GPPP).

INTRODUCTION

The green energy sector worldwide gained a significant focus and importance in the recent years. The combination of unstable and unexpected fluctuations of crude oil prices, together with a growing awareness to environmental issues is creating opportunities to develop power production projects based on green energy. Governments, international entities and major investment bodies allocated funds and establish regulations to encourage developers to pursuit this path. Areas of investments include all aspects of green energy, from hydro based to sea waves, through solar, wind, tides and many new initial explorations.

Within this group of green energy resources, geothermal fluid as resource is somewhat standing up. First, it has already gained significant experience via installed base of various technologies around the world and in a verity of resource characteristics. Second, between all of the known forms of green energy, it is the most sustainable, reliable form, that has already proven its ability to serve as base load contributor to the grid, with ability to deliver relatively calculated financial forecast.

Upon approaching a GPPP, the developer needs to understand the full path from concept to commissioning. Each building block of the project is based on the previous one, and understanding them, with the right expectations for investment and long term ROI, help the developer to reach the commissioning stage and the start of revenue stream faster and in a controlled and foreseen financial stream. In this paper the major building blocks of the GPPP is examined.

1. MAJOR COMPONENTS OF GPPP

This review assumes that the geothermal field location is defined, all regulations and incentives are known, and concession, licenses, right of ways and permits are approved and granted. The building blocks we shall discuss are for the actual project development on site.

Major and sub major components –

1.1. Geothermal Field

1.1.1. Assessment of potential

1.1.2. Field development and surveys

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1.1.3. Drilling

1.2. Agreements

1.2.1. PPA

1.2.2. CDM

1.3. Power plant

1.3.1. Design point data

1.3.2. Technology

1.3.3. EPC, Delivery and other activity

1.3.4. Balance Of Plant (BOP)

1.4. Commissioning

1.4.1. Startup

1.4.2. Testing

1.4.3. O&M

2. NATURE OF RISK ASSESMENT OF GPPP

By definition, developing GPPP is a matter that calls for majority of the financial resources to be invested at the beginning of the project. With slight variations between different technologies that will be implemented in the solution, one can safely say that majority of the investment in GPPP occurs BEFORE electricity production and revenue streaming starts. In addition to the fact that no cost of "fuel" is requested throughout the life of the power station, two other major reasons to this unique investment module exist:

I] Cost of the field development and of the equipment is relatively high;

II] Cost of Operation and Management (O&M) is relatively (and very much technology depended) very low.

I]- Cost of field development: The higher side of the risk of developing GPPP is found in the rather early stage of the project- from the time of decision to develop the project there is a big uncertainty factor over the nature of the resource until the time of discharge tests of the actually drilled production wells. Green field development, up to drilling stage, can be accounted for half, or even more, of the total investment in GPPP. This is why a crucial factor of the proposed technology to generate the power is its ability to utilize the resource to its maximum. For this reason we strongly recommend to follow the phase of field development with a support of a professional consulting company, experienced with geothermal and geological project development. Professional survey which will result with better utilization of the geothermal field is influential over the whole live cycle of the power station. Not only the ability to identify the place to drill, but also to conduct a discharge test that will set design point of the wells in a way that it will not be overused and exploited, and to place the reinjection well(s) in a place that will not cool the production well out put but will re-fill the resources, and these are only few of the professional issues on stake.

II] – O&M: the cost of O&M of GPPP is related a lot to the technology used. Steam turbines are higher in efficiency, yet have higher cost of maintenance and need more operators that are more expensive because of the high pressured steam environment. ORC based turbines are much more durable and easy to maintain and can be controlled and monitored remotely.

3. MAJOR COMPONENTS OF THE GPPP –

3.1. Geothermal Field

The geothermal field is the "fuel" of the power plant. It is the most important, yet most unknown factor of the whole project. The more professionally made investment in this initial step of the project, the less risk factor there is.

3.1.1. Assessment of potential

There are many factors that determine what the actual value of a geothermal field is. Few to mention- composition of the geothermal fluid, pressure, temperature at bottom well and at well head, total durability, and many more. The assessment of the potential comes from a geological survey, test wells (slim holes), exploration and most important- actual production wells and their testing procedure and performances.

3.1.2. Field development and surveys

Once enough data is gathered, a plan to develop the field must be made- where to drill for production, for re-injection, what depth, how many wells. At this stage of the project the technology and the methodology should be rather clear. Other surveys may be required at this point, such as environmental impact survey.

3.1.3. Drilling

Drilling is made by professional specialized drilling companies. The art of drilling is an issue by itself, yet full cooperation between the geothermal consultant, geological survey company and the drilling company can ensure optimized results. In most cases the field development up to drilling activities is handled separately from the actual procurement and construction of the project. The developer is signing agreements for these two activities well ahead of the other agreements.

3.2. Agreements

In parallel to all activities on site, and regardless of licenses, permits and concession issues, the developer need to ensure an agreement to sell the electricity, and can also be engaged with procedure to earn more income by the CDM mechanism.

3.2.1. PPA

Power Purchase Agreement – with the off-taker of the electricity you are about to produce. There are many variations to this agreement. In addition to price and payment procedure, this agreement also set the procedure to connect and disconnect to the grid, the right to sell privately, or in spot prices.

3.2.2. CDM

Ever since the Kyoto agreement to reduce greenhouse gases, there is a procedure to receive, buy and sell the certificates that serve as proofs that an entity is actually contributing to reduce the green house gases. The idea behind this for the geothermal based power plants is that electricity generated by renewable and green energy, such as geothermal, is replacing the need to generate the same amount of electricity by polluting power plants.

It is essential that the developer is engaged with a reliable company specialized in CDM process as early as possible in the GPPP, as the quality of the documents and survey made in this subject may determine how high is the contribution the CDM can deliver to the streaming revenue.

3.3. Power plant

3.3.1. Design point data

Once (at least one) production well (s) is in place, there is a need to define under what condition it will operate. The discharge test is performed over a relatively long period, and as a result the well's deliverability curve is drawn as well as the fluid chemistry and other parameters. With the data obtained from several wells all parties gathered to define what are the operating parameters of the well-field.

This design point data, including temperature and pressure at well head, flow, level of steam and brine, NCG content and chemical analysis, are the foundation to the decision of the final technology and the detailed technical design of the power generating unit.

3.3.2. Technology

There are two different ways to generate electricity form geothermal fluid-

I] Steam turbine
II] ORC based turbine.

The key different between them- steam turbine can use only steam, and is more efficient in its ability to convert hot steam to electricity, and ORC turbines can use both liquid and gases to generate electricity, yet is less efficient.

There are many more differences, which need to be evaluated case by case. Out of the rest of the differences, the more important one to point out is that, steam turbines are manufactured as "standard" sizes, has longer delivery time and require more maintenance and operators. ORC turbine, of which Ormat to date is the only manufacturer with actual field experience, are design per project in relatively short delivery schedule, thus customized to the geothermal resource and are much less expensive to maintain and operate.

As a general recommendation, if the resource has enough steam with relatively low % of NCG, steam turbine is to be installed. ORC based turbines are recommended for all other cases, including the utilization of the brine part of the resource in steam turbine environment.

3.3.3. EPC, Delivery and other activities

After the design point data is set it is time to select the technology, perform the conceptual design and sign contracts for equipment and construction. There are several ways for a developer to actually 'make' the power station all the way to commissioning: Turnkey, EPC, and split scope (supply and construction separately). The selection of either option is very much dependent on the developer itself, the place where the project is carried out, financial factors, the suppliers, legislation and more.

In either case, it is important to notice that from time of contract signature to end of construction / commissioning, there is a time gap of between 15 to 36 months, depending on the various components and market demand. To-date, for example, generators lead time is about 12 months, and steam turbine lead time can be well over 24 months. Shortening this time is crucial, is can be achieved by parallel activities, such as on site civil work, BOP construction, foundations and alike during the time that the equipment is manufactured.

The most common method that Ormat is working in Turkey, as well as most other places, is supply only of the generating unit. The ease of installation, as well as the cost of labor if EPC is requested form Ormat, makes it the most business sense way to work. We are responsible for the whole generating unit (OEC), while the construction, and all activities related to the Balance of Plant (BOP) is better handled locally. Not only we save costs to the developer, but we also make it a habit to provide as much as possible work to the local market without compromising on the safety and quality of our systems.

3.3.4. Balance Of Plant (BOP)

The generating unit, is one component, that is designed based on the geothermal fluid arriving to its flanges, and leaving form the other end to the re-injection well(s). Anything that happens form the well head(s) to the generating unit, and form there to the reinjection well(s) is called "Balance of Plant". This part should be designed and constructed with same care as the rest of the plant. A lot can happen between well head and generating unit. Temperature and pressure need to be maintained, separation of steam and brine, release of NCG, all or partial, sedimentation in the pipes, special pumps to be installed…

3.4. Commissioning

The commissioning period is the time between the completion of construction and start start commercial production and selling the electricity.

3.4.1. Startup

The start up procedure includes operating the power station A-to Z, including connection to the grid. Normally a representative of the utility and maybe of the authorities is present at this phase.

3.4.2. Testing

Once all equipment is in place and connected, the whole power plant need to be tested. The testing period can take up to three weeks, depending on the power station.

3.4.3. O&M

Operation and Maintenance is the daily routine at the power station. The cost of O&M varies a lot with the nature of the resource, the technology, local regulations and more.

4. BUSINESS AND TEXHNICAL TIMELINE

The list below summarize the various steps needed from initial project improvement to O&M –

Start- time 0 (zero)

- Approval of project development program
- Engagement of geothermal resource consultant
- Resource preliminary study of existing data
- Definition of preliminary geothermal fluid parameters
- Preliminary power plant configuration
- Assign CDM consultant
- Environmental Impact Study (EIS)

60- 90 days

- Obtain permits, licenses & RoW for exploration & exploitation activities
- PPA or equivalent
- Geological and geophysical survey (gravity, magnetic, seismic, etc…)
- Drilling exploration well(s) (temp. grad.)

90 - 180 days

- Reservoir numerical model
- Define preliminary site data and wells location
- Determination of gathering system, plant location, T line, grid connection and access roads including estimated preliminary budget
- Determination of power plant within fence including estimated preliminary budget
- Advanced FS
- Finalize land acquisition, concessions, and all other permits

9- 15 months

- Drilling of first production well
- Well testing
- Update numerical model and resource data
- Drilling of production and injection wells

15-24 months

- Firm quotation for power plant
- Firm quotation for gathering systems, T line, etc...
- EPC agreement for power plant
- EPC agreement for gathering system, T line, etc…
- NTP to EPC MD1

24-28 months

- EPC of power plant
- EPC of gathering system etc…
- Construction- T lines and grid connection

36-40 months

- Testing and commissioning
- Operation phase