Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Integration of Drilling and Workover Services in the Geothermal Project Laguna Colorada

Carlos E. Garcia Antezana[1], José R. Pérez Villarreal[1]

[1] National Electricity Company (ENDE), O655 Colombia Avenue, Bolivia

carlos.garcia@ende.bo, jose.perez@ende.bo

Keywords: Integrated Drilling Services, Workover, Drilling, Geothermal Project, Sol de Mañana Geothermal Field.

ABSTRACT

The National Electricity Company (ENDE) of Bolivia in compliance with its obligations and responsibilities in the electric sector and its role in the energy productive chain is carrying out the Geothermal Project Laguna Colorada in the "Sol de Mañana" field, and has the purpose to supply renewable energy to the National Interconnected System (SIN), and contribute in the economic development of the country.

Taking advantage of the geothermal potential in the "Sol de Mañana" area, it will be the first project of its kind in Bolivia and one of the first in South America due to the extreme working conditions.

ENDE embarked on the challenge of drilling 25 new geothermal wells (vertical and directional) with an approximate depth of 2000 m. Furthermore, it requires two rigs with a winterization system to avoid problem of the freezing of the equipment due to the low temperatures in the area.

The project also contemplates doing workovers to run slotted casing in 4 existing wells and 1 minor workover. In addition, civil engineering work includes the following activities: a) Construction of water pits, b) Construction of rig foundation and cellars, c) Constructions of pads and d) Maintenance of access roads, internal roads and pads during drilling works.

ENDE has decided to use an Integrated Services contract model, where the principal contractor is responsible for managing the drilling operations and managing 40 different services subcontracts including the workovers.

ENDE plans to change the way it administers the project from an economic, operational and contractual point of view to improve drilling performance and reduce the Non-Production Times (NPT). This will be the first Integrated Services Project in Latin America and the highest in the world 5000 m above sea level.

1. INTRODUCTION

In 1988, the government of Italy, through Ente Nazionale per L'energia Elettrica (ENEL) with technical cooperation of Bolivian Oil Company (YPFB), drilled the first well in Bolivia.

The development of the Geothermal Project Laguna Colorada began in the 1970s, through a fund from Italy. Five wells were drilled from 1988 to 1992.

The depth of the wells drilled is as follows:

- SM-1: 1178.5 m
- SM-2: 1486.5 m
- SM-3: 1406.0 m
- SM-4: 1726.2 m
- SM-5: 1705.0 m

All of these wells produced steam except for well SM-4. However, well SM-4 has good permeability and could be used as an injection well. The well production varies between 350 to 370 t/h of two-phase fluid (brine/steam).

The drilling, together with further studies, revealed the potential of the reservoir and confirmed the existence of geothermal fluid at temperatures higher than 250 ºC and a generation potential of 350 to 300 MW (estimated).

In 2010, Japan International Cooperation Agency (JICA), and the government of Bolivia started discussions on the finances of the construction of a 100 MW geothermal power plant in Sol de Mañana field.

At present, the main sources of electricity generation are: thermal (66.5%) and hydro-electric (33.5%). According to the "Patriotic Agenda 2025", Bolivia has two important policies: commitment to supply electric energy for internal consumption and the diversification of the energetic matrix towards new renewable generation sources, including geothermal energy.

The main objectives of the project are the drilling of 25 deep wells, the construction of a power plant, and the construction of a 230-kV electricity transmission line of approximately 170 km for the connection with the SIN.

Garcia and Perez.

The scope of the works for the Integrated Services includes the drilling of an estimated 25 wells, of which 16 well are for the production of two-phase fluid (brine/steam) and 9 for reinjection of brine. It is also contemplated to complete the workover of 5 existing wells. For this it is necessary to supply 2 rigs with all auxiliary and complementary services, including the necessary materials, as well as other equipment for the workovers.

The drilling is scheduled to begin in the fourth quarter of 2021 for an estimated period of 36 months.

1.1 Study area

Geographically, the study area is located in the extreme southwest of the Bolivian high plateau, in the Potosi department near the border of Chile and Argentina, at an altitude of 4900 - 5000 m above sea level.

The Sol de Mañana field is located 20 km to the south of Laguna Colorada with the coordinates 67° 45´10" W, 22° 25´ 50" (Figure 1).

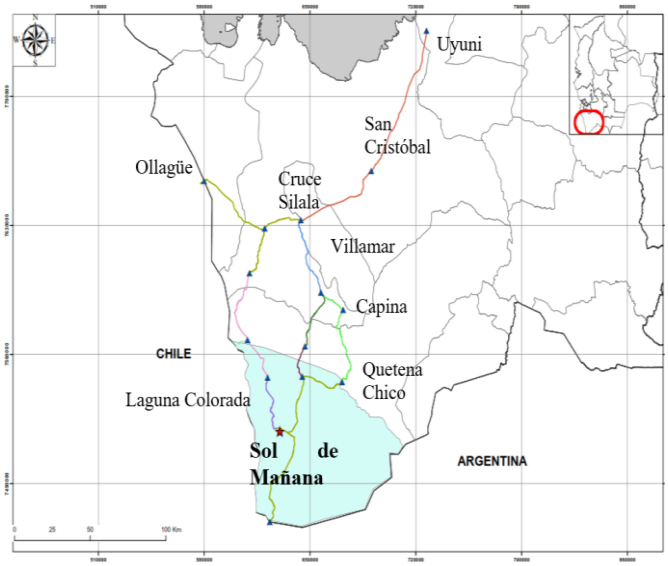

Figure 1: Location Map of the Study Area (ENDE, 2018).

2. INTEGRATED DRILLING SERVICES

For years, the industry has been using single discrete contract. Over time the drilling performance has improved, including notable technical advances. The next step is to integrate the entire well construction process.

The objective of the Integrated Services contract is to integrate the entire scope of well construction work with a proactive administration to reduce the risk in all phases of the project.

The advantage of Integrated Services contract is that instead of ENDE managing 40 subcontracts with different companies that provide a range of services, it is intended to have a single contract with a single company that combines all services requires to complete the project. This should reduce the need for ENDE to bill all services to the operator companies.

This type of contract helps companies that cannot provide all services for the execution of a complete drilling project.

The reasons for having an integrated service are:

- To improve operational efficiency by having one point of contact with the drilling contractor, and all the associated subcontractors and suppliers.
- Obtain benefits from discounts when contracting a large volumes of services with the drilling contractor.
- To reduce the management workload of 40 services.

Integrated Services are a success, as shown by examples of projects in Indonesia, which have been completed under this mode.

2.1 Drilling Plan

The wells to be drilled have been designed with an estimated deep of 2000 meters with an inclination of up to 30 degrees with respect to the vertical. The expected formation temperature at the bottom of the wells is approximately 240 - 250 ºC.

Prior to drilling wells, the pad should have:

- Rat hole to place the Kelly holder, mouse hole to place the drill pipes and facilitate their connection in the BHA.
- Welding of two lateral inputs with 2" threaded connection to the casing guide.
- Installation of 30" guide casing and overflow line.

The proposed design of the wells consists of 4 stages and the diameters of open hole and casing are as shown below:

- Stage 1: Hole 24”, @ 70 m depth, casing 18-5/8”.
- Stage 2: Hole 17-1/2”, @ 350 m depth, casing 13-3/8”.
- Stage 3: Hole 12-1/4”, @ 800 m or 900 m depth in production and reinjection wells respectively.
- Stage 4: Hole 8-1/2”, @ 2000 m or 1500 m depth in production and reinjection wells respectively.

The start of the curve (KOP) has been planned at a depth of 400 and 350 m in Stage 3 with a diameter of 12-1/4” for the production and reinjection wells respectively (Figure 2).

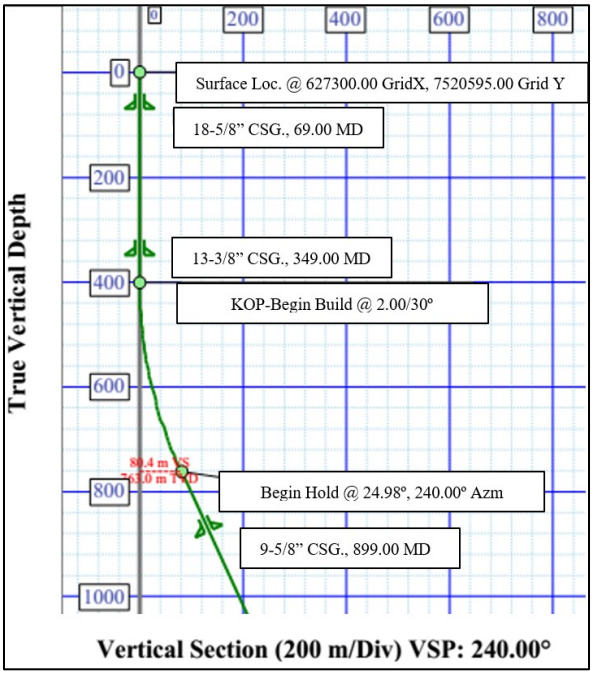

Figure 2: Directional Drilling Design.

Some data may vary in the final design or after the first wells are completed.

Measure While Drilling (MWD) will be used until searching the angle of the curve. For the next Stage the use of the single shot equipment for the directional control has been estimated.

Table 1 show the critical design point of directional drilling:

Critical point							
MD (m)	**INC (°)**	**AZM (°)**	**TVD (m)**	**EW (m)**	**NS (m)**	**VS (m)**	**DLS (°/30m)**
KOP-Begin Build @ 2.00°/30m							
400	0.0	240	400	0.0	0.0	0.0	0.0
Begin Hold @ 24.98°/240.00° Azm							
774	25	240	763	-69	-40	80	2.0
PBHL @1878.01 m TVD							
2004	25	240	1878	519	300	600	0.7

Table 1: Critical Point of design.

It is important to mention that the climatic conditions of the drilling site make it difficult for the rig to continue drilling without interruption. So, the rig must be protected against extreme cold. Is important to establish a system to avoid accidents in the pumping systems and in the pipes due to the ice, especially the fresh water from water wells that would freeze in the pipes without the use of special devices such as drain valves, electrically heated wire along the pipes, and others. The rig should have a “WINTERIZED SYSTEM” to avoid the freezing problems.

Due to the altitude of project it has been determinate that the rig must has a minimum capacity of 1200 HP, effective in situ, considering that at this elevation there is a decrease of power of up to 35 - 40 % in the internal combustion engines.

Figure 3, shows the stratigraphy expected in the first well to be drilled based on the existing wells in Sol de Mañana field, it is expected that the other wells will be similar.

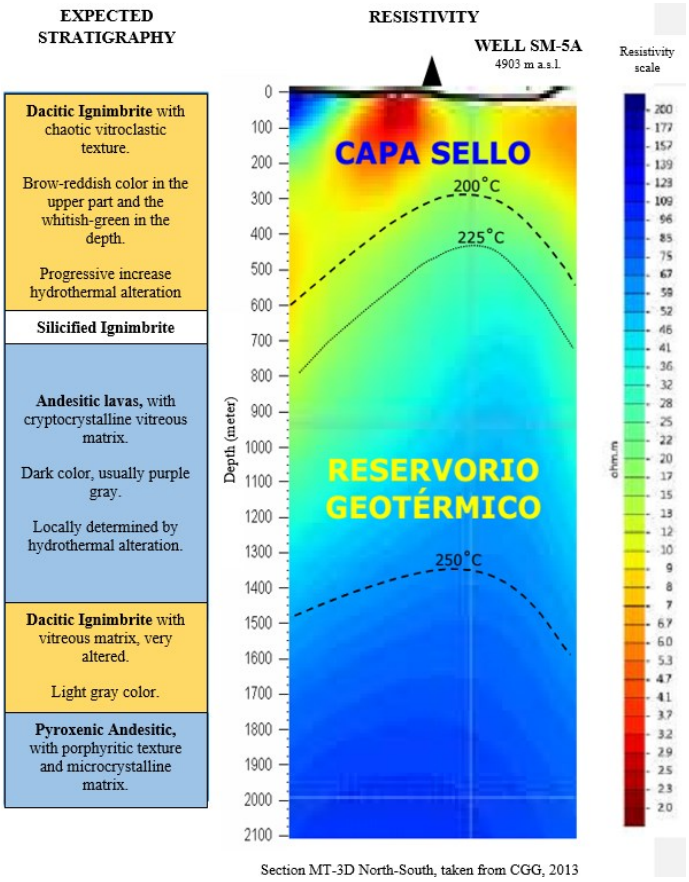

Figure 3: Expected Stratigraphy (ENDE, 2018)

Table 2 shows the estimated drilling times; however, it does not include the transfer time between wells on the same pad, or the transfer time to wells on different pads.

	Drilling Time (estimated)		
	Days	**Quantity**	**Time days**
Production wells	60	16	960
Reinjection wells	45	9	405
Workover	7	5	35
Total Wells		**30**	
Total Time (days)			**1400**

Table 2: Drilling Times (ENDE, 2018).

2.2 General Organization

For the Integrated Services to be functional, the project has the following organization: a) ENDE (Regulator and Supervision) b) Drilling Supervisor and c) Integrated Service Contractor (Drilling contractor).

The Integrated Services contractor will have an Integrated Service Project Manager, who will be responsible for all day to day project operations.

The Integrated Services contractor will have the following personal:

- Integrated Project Manager,
- Drilling and Workover Engineer (Senior Professional),
- Company Man,
- Day Superintendent,
- Night Superintendent,
- Contract Specialist,
- Finance Control,
- HSE Coordinator,

- Logistics Supervisor,
- Community Relations,
- Civil Works Supervisor and
- Logging and Testing Specialist.

The Drilling Engineer (Integrated Service) will communicates with the Drilling Supervisor to verify that operations are carried out according to the requirements of the operator company (ENDE).

In case there is a disagreement on any aspect, of the project a decision will have to be made in conjunction with ENDE. The Drilling Supervisor will communicate through the Integrated Service contractor to the subcontractors in the event of dispute.

It may happen that there will be a total disagreement. In this case ENDE has the responsibility to make the final decision regarding the well, and the Integrated Service contractor the decision regarding the rig.

Figure 4, show the project management team:

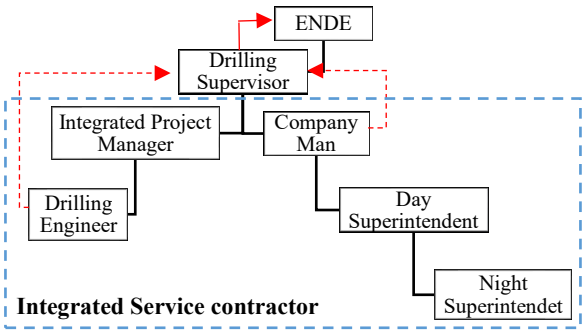

Figure 4: Project Management Team

2.3 Required Services/Subcontractors

The management of subcontractors and/or services is the key element of the Integrated Services concept.

The list of the required services is presented:

- Drilling and Auxiliary Services,
- Workover Service,
- Drilling Fluids Services,
- Cementing Services,
- Drilling Directional Services,
- Wireline Services,
- Air Drilling Services,
- Data Drilling Record Services,
- Well Geology Services,
- Drilling Waste Management,
- Liner Hanger 7” x 9 5/8”,
- Coring Services,
- Well Logging Services,
- Water Supply Services,
- Fishing Services,
- Communication and Data Transmission,
- Base Camp and Catering,
- Slotted Liner Service 7”,
- Casing Running and Inspection Service,
- Tubular Maintenance and Inspection (BHA, DP, etc.),
- Assembly of Well Production Test Equipment,
- Drilling Pad Maintenance and Clean Up,
- Diesel,
- Water Vacuum,
- Sensors,
- Well Head Installation,
- Welding,
- Crane,
- Ambulance,
- Rig Inspection,
- Handling Waste Management,
- Stimulation,

Garcia and Perez.

- Explosives,
- Civil Works Service and
- Integrated Service Management.

The type of contract that is handle in the project is “Time and Material” between ENDE and Integrated Service contractor and the type of contract that the Integrated Service contractor handles within the subcontractors and/or services are:

- Contract for minor services with personnel.
- Minor services contract without personal (per call).

The administration of subcontracts implies a greater burden on the Integrated Service contractor, so it is necessary to have a comprehensive system from the beginning of the project.

3. CONCLUSION

It is expected that the Geothermal Project Laguna Colorada will be a success. The concept of an Integrated Service contract will allow to ENDE and the Integrated Service contractor to work closely to optimize the drilling of high-risk wells in a safe and professional manner.

Good planning, organization and administration are the key for the success of the project.

One single contract will be used to help manage the complexity of diverse project.

REFERENCES

Agencia de Cooperación Internacional del Japón - JICA, Asistencia especial para la implementación del Proyecto de construcción de la planta Geotérmica Laguna Colorada (Fase 1 - Primera etapa). (2015).

Empresa Nacional de Electricidad (ENDE), Servicios Integrados de Perforación de Pozos Geotérmicos Profundos “ENDE-PGLC-PC-01/2018” (2018).

Organización oficial del Japón para el comercio exterior - JETRO, Estudio de factibilidad para la construcción de la Planta Geo termoeléctrica de Laguna Colorada, Potosí, Bolivia. (2008).

Schlumberger Company: public web page: Integrated Drilling Service, simplify drilling operations, well design and well construction with integration.