SW-CPDEP, Project Management Process for the Right Decision in Geothermal Field Drilling and Completion

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ABSTRACT
Drilling wells is probably one of the highest capital expenditures and source of risk for geothermal industries today. Drilling is employed starting from exploration, delineation, initial wells for production, and up to infill when existing wells production have declined. The estimated cost for drilling new wells for geothermal industry today is around 3 MM $ to 15 MM $, which requires a high level of decision making from high management levels.

To make the right decision on spending a high capital expenditure in drilling requires a diverse workforce, such as drilling engineers, geologists, production engineers, reservoir engineers, drill site manager, and others to start from the planning, design, to execution phases. Many times, different members of the group have different objectives. The geologist requires gaining field information while the reservoir engineer requires maximizing production rate and the drilling engineer requires lowering well costs. The main challenge in decision making is always on how to compromise among project team members in order to make the right decision.

This paper will illustrate the process and methodology of a project management process which Chevron Geothermal Indonesia has been using for its decision making process. The process, SW-CPDEP, consist of five phases and being executed by a multidisciplinary project team.

The result from applying this process was the success of the 2012 to 2013 Salak drilling campaign. Cost wise, it was estimated that 10 to 15 million dollars have been saved from the original budget. The steam supply from the drilled wells met the requirements. Water injection wells exceeded expectations, where two less wells were required and additional valuable information were gained, which later helped another project team to make a decision on a new PAD location for future infill wells.

1. INTRODUCTION
Drilling in geothermal is more expensive (cost/foot) than onshore oil and gas drilling. The main well cost driver for geothermal wells is the technical challenge that requires special tools and techniques to drill geothermal such as equipment with large diameters and are unique. It is estimated that the cost of drilling a new well is around 3 MM $ to 15 MM $. Aside from the high upfront cost of drilling new wells, another challenge is how to manage disparate well failure risks.

High upfront cost and the associated risks are the main concerns which require a high level of decision making from high management levels. Making a good decision will lead to the success of geothermal drilling projects. However, it difficult to make good decisions. Good decisions need to have clear objectives on the desired outcome; adequate information to assess the options; several possible well defined choices that reflect the company’s values, interests, and abilities; possible outcomes for each course of action; and learnings from previous experiences.

To make good decisions as stated above, drilling geothermal wells requires an interdisciplinary team workforce. Considering how the different functions involved in geothermal drilling interact can be useful in understanding the impact of decisions. Gathering the information from the interdisciplinary team and using their resources and knowledge strategically will be the key business strategies for the management process.

The strategic management process in Chevron has a systematic process of formulating, implementing, and evaluating cross-functional decisions that enable Chevron to achieve its objectives. The value of thinking strategically has made a significant impact on drilling performance. The strategic management process for geothermal drilling in Chevron is called the single well- CPDEP (SW-CPDEP). SW-CPDEP is used to provide guidance, set responsibilities, and establish the requirements for project management and operational governance that are required to plan and execute a single well or a group of wells.

2. SW-CPDEP AS SYSTEMATIC APPROACH IN DRILLING GEOTHERMAL
SW-CPDEP approaches five critical areas that cover how the geothermal industry does the following: define and assess the opportunity, define the strategic objectives, formulate the strategy to achieve the strategic objectives, implement and execute the coherent strategic plan, evaluate the strategic performance, and make corrective adjustments in the strategy. The sequence of SW-CPDEP is essential to deciding the appropriate strategy to develop into action and control.

SW-CPDEP was applied for drilling in Chevron Geothermal Indonesia during the Salak drilling campaign from 2012 to 2013 and it led to successful results. Cost wise, it was estimated that 10 to 15 million dollars were saved from the original budget. The steam supply from the drilled wells met the requirements. Moreover, water injection wells also exceeded expectations such that two less
wells were required. In addition, valuable information was gained which later aided the main project team for making a decision on a new PAD location for future infill wells.

2.1 Phase 1 SW-CPDEP - Identify and Assess Opportunity
A key point in phase 1 SW-CPDEP is the constant need to identify and assess the opportunities involved in the creation of access to new wells which deliver higher steam gains. The process in assessing the current steam gain position becomes the starting point for identifying the geothermal drilling needs. The identification of new opportunities will create the new ideas and new technologies to drill the new well.

Framing the project and intending to establish if the proposed well is a viable project and aligning it with the SBU Business Plan will be main task in Phase 1 (Figure 1). Decision executives make the decision to proceed into the next CPDEP phase or to stop, hold or recycle. The main objectives in Phase 1 are the following:

1) Communicate the well planning work process required to complete Phase 1 and subsequent phases via the SBU WC-CPDEP roadmap.
2) Document the cross-functional team that will steer the planning and execution process
3) Capture the business opportunity and establish the well objectives, scope, and frame
4) Identify preliminary uncertainties associated with the well
5) Develop a Phase 1 cost estimate, economics, preliminary rig schedule, long-lead analysis, and Phase 2 work plan

2.2 Phase 2 SW-CPDEP - Identify Uncertainties, Generate Alternatives and Alternatives Analysis
The key points in phase 2 are to integrate different perspectives on defining uncertainties and present and integrate objectives into an analytical framework. Starting from the uncertainties and value based well objectives (VBWO), the interdisciplinary team tries to generate alternatives and analyze alternatives with the understanding of key risks (Figure 2).

Phase 2 has the greatest impact on a project and it is where all viable well construction options are evaluated prior to detailed design work in Phase 3. The main objectives in phase 2 are to:

1) Continue the well planning process, remaining aligned to the phase 1 frame and objectives
2) Create a succinct list of cross-functional VBWO and an UMP.
3) Develop a wide range of well alternatives and the fact-based evaluation that they can achieve the VBWOs along with an understanding of key risks.
4) Prepare for the Phase 2 gate and gain approval to move to Phase 3.
Drilling geothermal wells have many uncertainties that the team would not know for certain. It may include several questions in drilling geothermal wells. What is the potential for hole collision at depth with wells drilled from other pads? Do we expect competent formation at the 13-3/8” casing shoe? What is the depth of the P50 ToR?

A general framework for uncertainties (UMP sheet) will be developed to distinguish and identify uncertainties, VBWO Impact, action items, completion date, and status. The elements in this framework will be applied to analyze conditions of managing uncertainty from the strategic and operational perspectives.

Alternatives for drilling geothermal wells are generated from the uncertainties and VBWO. The scope of the alternatives should cover the hazards, geologic targets, upper completion, well locations and trajectory, casing size and setting depths, tree type, rig types, reservoir management requirement, facilities, and future intervention requirements.

Once the alternatives have been identified, a method of evaluating them and selecting the most appropriate one needs to be used to arrive at a decision before entering Phase 3. Decision executive will approve to continue to Phase 3 if the project team can show the appropriate frame in this project, the creative and doable alternatives, meaningful and reliable information, clear value and trade-offs, logically correct reasoning, and commitment to action.

2.3 Phase 3 SW-CPDEP – Develop Preferred Alternatives

The interdisciplinary team carefully considers the alternatives to develop a preferred alternative described in Phase 2. The preferred alternative provides a framework covered in Phase 3 to guide the collaborative and development wells. The key point in phase 3 is to provide detailed well engineering and AFE development for the selected alternative, based on the approved basis of design (should include the Earth Model). Once the basis Of design (BOD) is approved, each functional group works to refine the well design using the process steps (BOD, well design risk assessment, update economic parameters, G&G well evaluation surveillance plan, drilling program peer review, use MOC for BOD change, prepare AFE Document for signing). Figure 3 will describe the details needed to be done in Phase 3.
Under the preferred alternative, an understanding of risk management is required since many risks such as MASP, shallow subsurface collision issue, H2S, magmatic gases, etc. The process of identification, analysis, prioritization, and either acceptance or mitigation of uncertainty is required in the risk management plan. A risk management assessment needs to be completed by the team to quantify the potential for losses in an investment and the appropriate action. Inadequate risk management can result in severe consequences for geothermal drilling such as personnel injury, delay in operations, equipment damage, tripping hazards, environment spill, mud overflow to surface, etc. In Chevron, the interdisciplinary team does the risk assessment as an opportunity to create value. It is not possible to eliminate all drilling, completion, and intervention risks, but managing that risk appropriately is an important value driver. The foundation of the risk management philosophy is to protect people and the environment.

Risk assessments in Chevron are appropriate in Phase 2 (of the alternative design options), Phase 3 (of the selected well plan), Phase 4 (of the detailed procedure), and Phase 3 and 4 (of changes in MOC). All RA require the participation of the cross-functional team for effective implementation, with the exception of some WC-MOC RA which deal with D&C only issues. DSM / WSM shall participate in Phase 3 and Phase 4 RA, as well as in WC-MOC RA and should be considered for Phase 2 RA. Business Partners participation should be considered for Phase 3 and Phase 4 RA, as well as in WC-MOC RA.

2.4 Phase 4 SW-CPDEP – Execute
Approval of the final well design should occur not later than the early part of Phase 4. The focus items in phase 4 are drilling program lock and sign, pre-spud meeting, regulatory notices to government, mobilization, database system, monitoring system, and using the MOC process for change. This phase covers the development of the execution procedure, well construction operations and handover to production. Putting the strategy in place and getting the individuals in the team to participate fully in executing the functional part of the strategic plan successfully is the essential part in Phase 4.
During the Phase 4, the management of change (MOC) is the best practice in geothermal used to ensure that all changes to a process are properly reviewed and any hazards introduced by the change are identified, analyzed, and controlled before resuming operations. To make the changes, the MOC is requires an interdisciplinary team composed of the drilling engineer, geologist, production engineer, reservoir engineer, drill site manager, etc. The different perspectives in terms of understanding the impacts must be considered before making any changes. Changes in geothermal drilling must be evaluated for how it affects the operations. To have a better understanding of changes, the interdisciplinary team needs to do the risk assessment for this change.

For the case example, well “A” was drilled during the Salak drilling campaign in 2012 to 2013 and the original plan was to run a 10-3/4” combination of perforated and blank liners and cementing the blank liner. However, the team experienced total losses while drilling the 12-1/4” hole section at 4999.5 ft MD and was not able to gain any returns. Due to the losses, the team decided to cancel running the 10-3/4” combination of perforated and blank liners and cementing the 10-3/4’ liner because cancelling the cementing of the 10-3/4” blank section will eliminate the risk of a cementing job under TLC condition and prevent zone damage from the losses. The interdisciplinary team identified the schedule impact and risks and notified the impacted parties of the risks. Due to the cementing management of change in that well, additional value, estimated to be around 1.6 M, was created.

2.5 Phase 5 SW-CPDEP – Operate and Evaluate

Phase 5 outlines a comprehensive look-back process covering all aspects of well construction compared to the initial plan. The Geothermal drilling team establishes processes to identify areas where success was achieved, opportunities for improvement exist, and how these lessons / best practices shall be incorporated in future well designs/operations and if / how these should be shared globally. D&C lesson learned, RUMS and UMP close out, well testing, economic lookback, and VBWO Lookback will be main points for discussion in Phase 5 (Figure 5).

<table>
<thead>
<tr>
<th>Milestone/Deliverable Task</th>
<th>Project Type</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Post Drilling / Completion Lookback</td>
<td>All</td>
<td>RE (G&amp;G for Exp)</td>
</tr>
<tr>
<td>Drilling and Completion Lesson Learn</td>
<td>All</td>
<td>DE</td>
</tr>
<tr>
<td>Economic Lookback</td>
<td>All</td>
<td>RE</td>
</tr>
<tr>
<td>VBWO Lookback</td>
<td>All</td>
<td>RE</td>
</tr>
<tr>
<td>2. Database Management</td>
<td>All</td>
<td>DE</td>
</tr>
<tr>
<td>3. End of Project Meeting</td>
<td>All</td>
<td>RE (G&amp;G for EXP)</td>
</tr>
<tr>
<td>End of well lookback for rig crew</td>
<td>All</td>
<td>DE</td>
</tr>
<tr>
<td>Phase 5 Lookback meeting</td>
<td>All</td>
<td>RE (G&amp;G for EXP)</td>
</tr>
</tbody>
</table>

Figure 5: Well Construction – CPDEP Phase 5

After the evaluation process in Phase 5, corrective adjustments are desirable. Strategies may need to be modified because they are not working well or because of changing conditions. The interdisciplinary team can test out the ideas, technologies, and learnings in terms of what works and what does not work.

2.6. Salak Drilling Campaign 2012 – 2013 Result

During the last 2012 to 2013 Salak drilling campaign, a total 17 wells were drilled. This was composed of 11 new wells, re-entry on 2 wells, workover on three wells, and a stimulation job on one well. In this campaign, Chevron Geothermal Indonesia also drilled the first geothermal multilateral well and the deepest geothermal well in Indonesia which reached 6200ft below sea level. As a final step, the team tried to evaluate the effectiveness of the SW-CPDEP process in the Salak drilling campaign from 2012 to 2013. In the end, the result was that the utilization of SW-CPDEP in the Salak drilling campaign from 2012 to 2013 was effective in improving both drilling and completions operations in order to achieve goals.

The successful performance of the Salak drilling campaign from 2012 to 2013 can be summarized in the following list:

1) Improvement of footage/day KPI compared to the previous Salak drilling campaigns. The number of footage/day improved in Salak drilling campaign from 2012-2013, increasing to 380 ft/day from 329 ft/day in 2008-2009 and from 301 ft/day in 2006-2007. Year by year, it showed a positive trend which demonstrated the ability to drill faster in safe operations as shown in Figure 6. Higher ROP and better flat time efficiency were the keys of this improvement in footage/day (Figure 7).
2) The actual cost during the Salak drilling campaign in 2012-2013 was lower than the planned cost as shown in Figure 8. The actual cost was estimated to be 14 percent below the planned AFE mainly due to the more efficient drilling with the higher ROP. The improvement through SW-CPDEP process can aid in identifying opportunities for improvement and the lessons learned can be used in future well operations. Through the SW-CPDEP process, drilling can improve through corrective adjustments.

3) During Salak drilling campaign from 2012-2013, the steam supply produced was higher than the P50 estimate (2602 KPH vs 2195 KPH) and the injection capacity was also higher than planned (2450 KPH vs 2000 KPH) from less wells. In addition, well deliverability estimation was improved compared with previous drilling campaigns. The result is shown in Figure 9.
The Salak drilling campaign from 2012-2013 showed a significant reduction of stuck pipe nonproductive time (NPT) compared to the previous drilling campaigns as shown in Figure 10 and Table 1. It was estimated that the stuck pipe time of total NPT time was reduced by 43.3% in the Salak drilling campaign from 2012-2013 compared to the last drilling campaign. Waiting on permit and delay in mobilization because of communication issues were one key factors for NPT in 2012.

Table 1: NPT and Stuck Pipe – Drilling Campaign

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Total Well NPT</td>
<td>12.7%</td>
<td>20.0%</td>
<td>13.3%</td>
</tr>
<tr>
<td>Stuck Pipe event</td>
<td>24</td>
<td>44</td>
<td>7</td>
</tr>
<tr>
<td>Number of side tracks due to stuck pipe</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Stuck pipe time of total NPT time</td>
<td>40.3%</td>
<td>50.9%</td>
<td>7.6%</td>
</tr>
<tr>
<td>Stuck Pipe time of total well time</td>
<td>5.1%</td>
<td>10.2%</td>
<td>0.9%</td>
</tr>
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</table>
3. CONCLUSIONS

1) The purpose of the SW-CPDEP is to provide guidance, set responsibilities, and establish the requirements for project management and operational governance required to plan and execute a single well or group of wells across the upstream organization.

2) SW-CPDEP is a systematic approach in geothermal drilling which approaches five critical areas that cover how the geothermal industry defines and assesses the opportunity, defines the strategic objectives, formulates the strategy to achieve the strategic objectives, implements and executes the coherent strategic plan, evaluates the strategic performance, and makes corrective adjustments in strategy.

3) SW-CPDEP has been applied for drilling in Chevron Geothermal Indonesia during the Salak drilling campaign from 2012-2013 which produced successful results. SW-CPDEP can help interdisciplinary teams in working strategically to get to a good decision to meet steam supply requirements, eliminate risks, and achieve dollar savings.

REFERENCES


