



Oil Sands Drilling and Completions Needs Identification, Technology Scan, Gap Analysis and Prioritization

**Final Report
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Prepared for Natural Resources Canada

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1. Project Description

1.1.Motivation

As any observer of the oil sands industry knows, capital and operating costs of oil sands projects have increased significantly in recent years. Cancellations and postponements of major oil sands projects for reasons of excessively high costs were taking place before the price of oil started its decline in the second half of 2014. Cancelled or deferred projects include the \$11.6 billion Voyager upgrader project and the \$11 billion Joslyn mine project by Suncor and Total, and the multibillion-dollar Corner project by Statoil. In general, high costs have diminished the economic attractiveness of oil sands projects when oil was at US\$100 per barrel, and are now threatening the industry with numerous additional project cancellations with oil in the range of US\$30-\$50 per barrel.

It is crucial to reduce costs in order to sustain the industry. The value targeted by this project to reduce costs and improve performance and recover more of the bitumen resource left in the ground by thermal technologies.

This project was launched in February 2015 in the context of the Oil Sands Competitiveness Initiative of Natural Resources Canada.

1.2.Background

The bulk of capital costs in Steam Assisted Gravity Drainage (SAGD) and other thermal processes relates to drilling and completion activities. SAGD project economics and environmental performance can be significantly improved through the application of emerging technologies to bring down the cost of drilling and completion.

Targeted technologies would include but are not limited to:

- Improved drilling methods;
- Higher accuracy and well placement precision;
- Lower cost measurement and instrumentation technologies.

Improving recovery and production from more precise and better designed wells will reduce wasted steam and improve the steam to oil ratio. These technologies will also access more of the oil that is left behind between well pairs and reduce environmental footprint, including greenhouse gases and land and water impacts.

1.3.Scope

The project is a networking process supported by subject matter experts to articulate the challenges and identify the needs, review the existing technologies, and scan for new technologies.

There were 2 phases to the project:

1. Phase 1. Identification of Needs, Technology Scan, Gap Analysis and Workshop (between March 1 and March 31, 2015)
2. Phase 2. Inventory of Potential Technology Solutions, Stakeholder Engagement, Prioritization, and Report (between March 1, 2015 and March 31, 2016)

Phase 1

The identification of needs involved subject matter experts that surveyed industry information and consulted with oil sands operators to understand and list existing needs that could be filled by the development of new technologies. The technology scan was performed by the same subject matter experts to identify prospective areas of technology development. The workshop brought together industry stakeholders to learn about project findings, provide feedback and contribute to the implementation of Phase 2.

Phase 1 was completed between March 1 and 31, 2015.

Phase 2

The gap analysis matched needs to prospective technology opportunities and was performed by the same subject matter experts. The research inventory listed relevant existing research efforts to guide implementation and avoid duplication. A series of meetings brought together industry stakeholders to learn about project findings, provide feedback and contribute to the potential implementation of recommendations.

Phase 2 took place between March 1, 2015 and March 31, 2016.

This final report provides an account of project activities, key findings and recommendations.

2. Phase 1 Results

Phase 1 focused on needs identification and a technology scan. The key activities were:

1. Preparation and delivery of a needs questionnaire
2. Scan of available near-commercial technologies and discussions with technology providers
3. Workshop
4. Phase 1 reporting.

2.1. Needs Identification

PTAC subject matter experts prepared a confidential questionnaire, which was 10 pages long and contained 60 questions, that was administered to 4 oil sands companies which are part of PTAC's Phoenix Network. The oil sands companies were asked to provide answers by email as best as possible given the short timeframe. Then, the subject matter experts contacted the oil sands companies to finalize the information provided through a telephone discussion.

2.2. Technology Scan and Gap Analysis

The subject matter experts had been carefully selected based on their technical and field experience with new drilling technologies. Thus, the initial step in the technology scan was to rely on the experts' views of potential new technologies. The subject matter experts added information to their initial review by contacting a number of technology providers to obtain relevant detailed information.

The technology scan covered the specific technical areas outlined below.

Drilling Challenges:

- Dealing with the ellipse of uncertainty including sag during drilling;
- Precise well placement of producer based on geological and reservoir engineering design (+/- 0.5 metres vertical / 1000 metres);
- Precise well placement of producer based on live drilling data integrated into and updating the geological and reservoir engineering models;
- Precise well placement of injector 4-6 metres away from the producer;
- Speed of drilling.

Areas for Solutions

- Best practices
- Improved logging and inspection tools with 3D visualization to allow for tactical changes during the drilling process to avoid shale barriers and other impairments and to safely place the producing well very close to the bottom of the reservoir;
- Drilling automation: there are multiple opportunities to use robots, sensors, logic controllers, analytics and other forms of automation to increase the efficiency, speed and safety of drilling;
- Cost effective solutions: tubulars, connections, logging, cementing;
- Technologies may include sensors, GIS, faster and larger bandwidth data transmission technologies, and analytics;
- Forward ranging ahead of bit.

2.3. Workshop

The purpose of this workshop was to document challenges, identify solutions and share information regarding improved drilling accuracy and well placement precision in SAGD in order to reduce costs and to improve performance. The workshop agenda included:

- Review of current practices
- Information sharing on current practices
- Review of best practices

- Review of available commercial and near-commercial technologies
- Facilitated discussions about opportunities for technology development and for Joint Implementation Projects (JIPs).

The workshop allowed for knowledge sharing about opportunities for cost reduction and performance improvement in areas such as pad drilling and construction, True Vertical Depth (TVD) measurement, rotary steerable systems and drilling tools, cementing and wellbore integrity, ranging, and formation evaluation.

The workshop registration was 21 people from senior oil sands companies.

2.4.Phase 1 Reporting

The Phase 1 report was prepared by PTAC and delivered to NRCan effective March 31, 2015.

3. Phase 2 Results

3.1.Inventory of Potential Technology Solutions

A total of 20 opportunities for technology development and JIPs were identified and are listed below:

1. Precise TVD Measurement
2. Improved Thermal Cement
3. Corrosion Logging through the Tubing
4. Passive Ranging Tool
5. Casing Expansion Joints
6. Active Ranging with Limited Access
7. Gyro Measurement While Drilling (MWD)
8. Formation Evaluation
9. Sonic Tool
10. Electrical Drilling Rig
11. Co-generation
12. Monobore SAGD Wells
13. Well Barrier Tool
14. Liners Smaller than 7"
15. Pad Design
16. Ranging Field Trial

17. Wells that Follow Pay
18. Drilling Mud Recovery
19. Waxing Liners
20. Multilateral Junction

3.2. Stakeholder Engagement

A number of meetings and interactions took place between oil sands producers in the PTAC Phoenix Network and technology developers with potentially attractive solutions. In particular, review meetings were conducted on March 31, 2015 and September 9, 2015 to review the status of precision drilling project proposals. In addition, the Phoenix Network Steering Committee met monthly through the project period (2015-16) to ensure governance oversight. Finally, the multilateral junction project team met periodically during 2015-16.

These meetings with senior oil sands producers provided close interactions between technology solution providers and oil sands companies for the purpose of aligning users and providers of technology. However, the development and launching of JIPs was severely affected by budget cuts imposed as a result of low oil prices and the industry downturn.

3.3. Prioritization of Technology Implementation Opportunities

The 20 opportunities for technology development and JIPs that were identified earlier were reviewed internally by the participating oil sands companies and the PTAC subject matter experts. A meeting was arranged to prioritize the opportunities, which resulted in 5 high value projects being pursued with specific action items. The projects that were further developed during Phase 2 are described below:

1. Precise TVD measurements

Precise measurements of True Vertical Depth (TVD) are critical in SAGD because total recovery is maximized by placing the producer as close as possible to the bottom of the reservoir while staying inside the reservoir. Any reservoir volume below the producing well will be stranded and not produced. If the producing well is drilled below the reservoir, production will be severely impaired because the non-reservoir rock immediately above the producer will baffle or isolate the producer from the reservoir. Thus, precise knowledge of well placement is critical, including TVD. This project involved a new approach to measure depth using two available well parameters. A study was conducted to determine the feasibility, reliability and cost of the new approach. Pending positive conclusions from the feasibility study, the next step would be to advance a field trial JIP with interested oil sands companies.

2. Monobore SAGD Wells

The monobore concept could significantly reduce costs of drilling SAGD wells but would entail risks that are not fully understood. A preliminary study could be considered to better

understand risks and potential cost savings. Critically, a number of field trials would be needed to prove and fully understand the risk-reward balance.

3. New Active Ranging Technology

Ranging refers to the guidance system that allows the injector well to be drilled at a precise distance from the producer well. A novel system currently being developed would allow costs to be reduced but the precision performance of the system would need to be demonstrated by conducting field trials. At the present time the novel system is only applicable to shallower SAGD well pairs. Future technology improvements include accuracy and power advances. The technology could also be used for precisely placing infill wells and avoid collisions with observation wells.

4. New Passive Ranging Technology

The novel technology is being developed that uses a systems approach to reduce costs while maintaining accuracy. The novel system would need field demonstration trials to prove the cost and performance claims.

5. Multi-lateral Junction for SAGD

In order to reduce costs and reduce environmental impact, when the geology allows it, conventional oil and gas producers may choose to drill multilateral wells. In these wells, a single vertical or dedicated wellbore is drilled from surface; at depth, a multilateral junction is installed from which a number of laterals penetrate the reservoir. Costs and surface environmental impact are reduced because only one wellbore needs to be drilled from surface to service two or more horizontal wellbores in the reservoir. There are different levels of junction defined by TAML, the Technical Advancement for Multilaterals Association.

This approach could also be applied to SAGD wells in the oil sands; however, SAGD operating conditions are far more severe than in conventional applications because of steam injection and the high temperatures to which the well is subjected. The first step in implementing this project would be to perform a feasibility study to clearly understand design requirements and costs, as well as the real potential for overall improvements in costs, production, steam-to-oil ratio, and environmental impact.

4. Conclusion

The project was initiated as scheduled. Phases 1 and 2 were completed within the approved budget and schedule. The deliverables included needs identification, the technology scan and gap analysis, workshop and stakeholder engagement per the project scope. In addition, project opportunities were identified, prioritized and selected for development. In 2016 onwards, JIPs based on the results of this project remain under development and are considered for investment by selected oil sands producers; however, substantial uptake will depend on the re-establishment of technology development budgets by industry and governments, which, in turn is dependent on economic conditions.