Eavor-Lite Demonstration Project
2506 (G2019000423) / R0160681

Final Confidential Report
Submitted on: January 11, 2020

Prepared for
Alberta Innovates and Emissions Reduction Alberta, Maureen Kolla

Prepared by
Eavor Technologies Inc
Matthew Toews, Chief Technology Officer, matt.toews@eavor.com
Bailey Schwarz, Lead Engineer, bailey.schwarz@eavor.com

Contents

List of Tables

List of Figures

1. Executive Summary

The purpose of this project was to demonstrate the Eavor-Loop™ system at full-scale, to enable global commercialization. This disruptive technology provides clean, scalable, dispatchable heat and power. The Eavor-Loop™ Demonstration Project is a fully integrated prototype closed-loop geothermal system with a novel downhole well design and best-in-class thermodynamic efficiency. The technology solves many of the commercial and technical issues with traditional geothermal, enabling widespread application in new markets.

Eavor-Loop™ consists of connecting two vertical wells (a well pair) at depth with several horizontal multilateral wellbores several kilometers long that are isolated from the reservoir, forming a closed loop system. The horizontal section is landed in a hot geological formation with sufficient temperature of 100°C or higher. A working fluid is then circulated through this closed loop and brought to surface, where the thermal energy is either sold directly or converted into electricity for sale. It is a completely closed loop system with no flow into or out of the rock formations, and no exit at surface. There is no fracking, no GHGs or CO2 emitted during operation, no earthquakes, no water use, no produced brine or solids, and no aquifer contamination. It collects heat from the natural geothermal gradient of the earth, at geographically common rock temperatures such as warm sedimentary basins where oil and gas resources are co-located. The technology is scalable as there is no need for high temperature volcanic hotspots, and no need for permeable aquifers or hydrothermal flow capacity. This makes it possible to scale up to thousands of repeatable wells with standard power modules, without being held back by a scarce resource and high-risk exploration – a global geothermal "resource play".

The Eavor-Loop™ Demonstration Project is a full-scale prototype of the Eavor-Loop™ technology. The purpose of this project was to de-risk the key technical components of Eavor-Loop™. The project consisted of a large U-tube shaped well with 2 multilateral legs at 2.4 km depth, and a pipeline connecting the two sites at surface, as illustrated in Figure 1. The technical objectives were to: 1) drill and intersect a multilateral Eavor-Loop™ with 2 laterals, 2) seal the Eavor-Loop™ without steel casing, and 3) validate the thermodynamic performance and demonstrate thermosiphon. The power generation component of Eavor-Loop™ was not included in this project, as this is a commercial off-the-shelf item and had not been identified by customers as a significant commercial risk. Removing this from scope allowed for the most cost-effective and quickest path to commercialization of the technology.

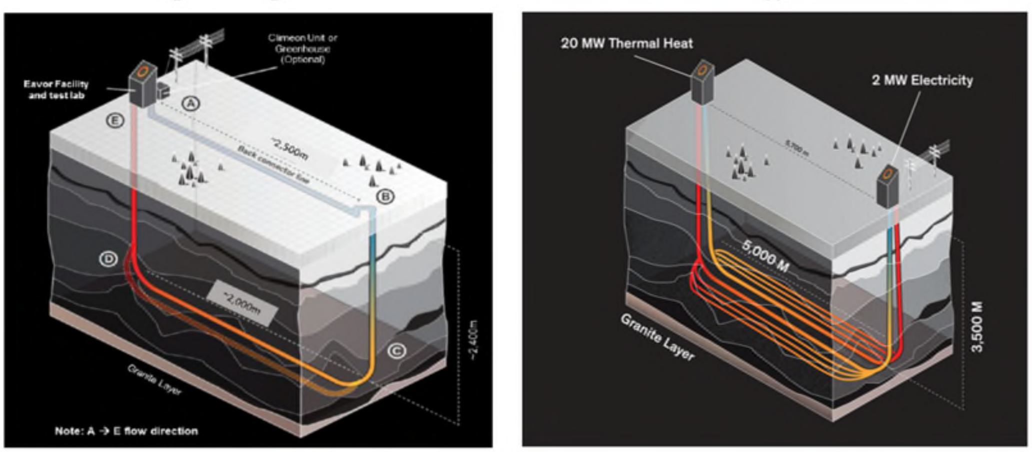


Figure 1 - Eavor-Loop Demonstration Project (L) vs. Full Commercial Scale (R)

This project was executed successfully, demonstrating that an Eavor-Loop™ can be drilled, sealed, and operated purely driven by a thermosiphon effect with thermodynamic results in agreement with the predicted output from the thermodynamic models. This has ultimately unlocked a new source of geothermal energy that is now ready for commercial deployment. A summary of the key technical objectives and outcomes is outlined in the Table 1 below.

Technical Objective	STATUS	Summary of Results
1. Drill and intersect a multilateral Eavor-Loop with two laterals	✓	LEG-2 was successfully intersected on September 1, 2019
	✓	LEG-1 was successfully intersected on September 11, 2019
	✓	Drilling program was completed and rigs were demobilized on September 14, 2019.
2. Create a closed system by chemically sealing the Eavor-Loop (Rock-Pipe™ completion)	✓	9 x formation integrity tests to 5 MPa performed throughout drilling and upon completion of drilling program with > 97.5% of pressure maintained.
	✓	Current operation leak off rate is < 1 m3/d.
	✓	Visual samples and filter differential pressure monitoring indicating negligible solids production, facility has been running at ~95% uptime since Dec 4, 2019 start-up.
3. Validate thermodynamic performance and demonstrate thermosiphon	✓	Thermosiphon has been fully operational, ongoing circulation without use of pump since Dec 4, 2019 start-up.
	✓	Preliminary thermodynamic model validation has been completed with measured performance within 2% of predicted (over first year operations).
	✓	Ongoing data collection and validation to prove out simulation capability over longer time frame. Third party validation of preliminary results received in August 2020.

Table 1 - Summary of Key Technical Objectives

2. Introduction

2.1. Sector Overview

Over the past decade wind and solar have been the renewable energy source of choice with increased manufacturing economies of scale and improvements in technology contributing to a precipitous decline in cost. Both wind and solar are variable power sources that produce electricity when their fuel, wind or sun, is available. Advanced very low or zero-emitting technologies that can be dispatched to meet energy demand are needed for electricity grids to transition to a net-zero carbon future. The power grid of the future needs a zero-emitting load-following resource “ZELFR”. Further, in northern Europe and North America almost 50% of total residential and commercial energy demand, and therefore carbon emissions, is for heating rather than electricity. These are two of the fundamental problems facing the energy transition. Geothermal is a natural fit for these two unsolved issues but it has remained a niche solution because of its need for a hard-to-find hot but permeable aquifer – a hydrothermal resource. This requirement can add tremendous cost, risk, and delays to traditional geothermal projects, and is limited to a tiny geographical area of the world. This is why, despite being around for over 100 years, geothermal still only accounts for < 0.3% of the world’s energy.

Further, while Traditional Geothermal has had a flat or slightly increasing cost per unit over the last decade, Wind, Solar, or Shale oil/gas wells have each shown a tremendous cost decline (see Figure 2). This “experience curve” for these energy technologies is typical and similar to the experience curve exhibited by any manufactured product whether its electric cars, smartphones, or LED displays; the declines are driven by standardized, repetitive operations and benefit from incremental improvements, as well as breakthrough technologies incentivized by a growing market.

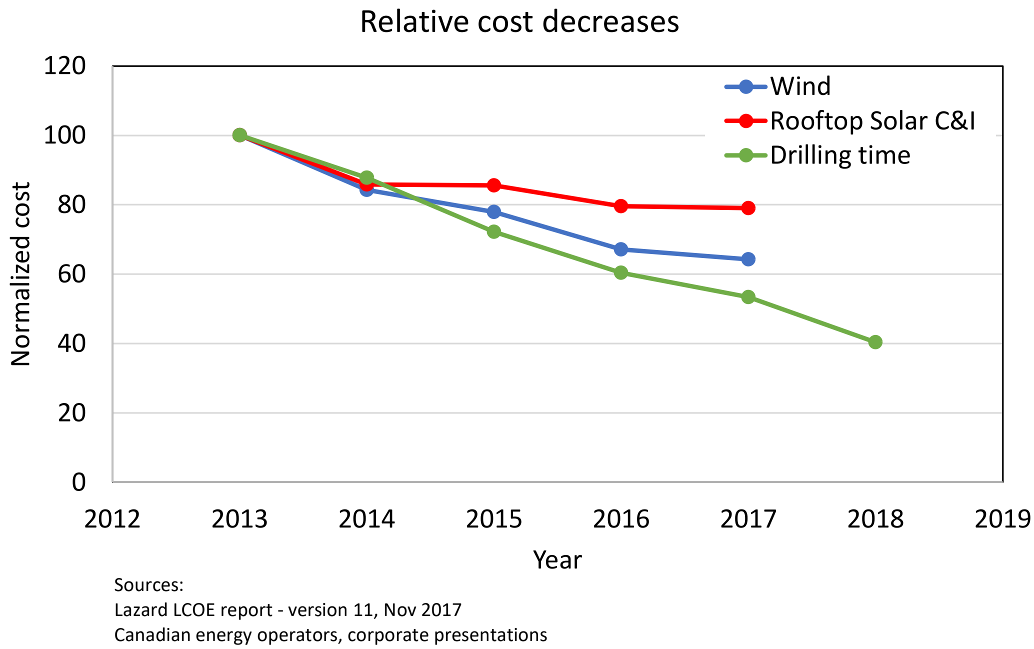


Figure 2 - Normalized learning curve for Wind, Solar, Drilling

Therefore, for geothermal to solve the two energy problems identified above it must be a scalable standardized manufactured product, applicable geographically to a large part of the globe, environmentally benign, dispatchable or load-following, low risk, and competitive cost.

The primary technical challenges in reaching these qualities are to a) eliminate the hydrothermal resource requirement, and b) develop drilling technology that can be used to drill deep enough to access hot rock nearly anywhere on Earth. The Eavor-Lite project addresses the first challenge, to demonstrate a closed-loop geothermal system that is largely independent of geology.

2.2. Knowledge and Technology Gap

The key difference of Eavor-Loop™ relative to existing geothermal technology is that it is a completely closed-loop: It is simply a buried-pipe system, akin to a deep radiator or heat exchanger. The technology is scalable as there is no need for high temperature volcanic hotspots, and no need for permeable aquifers or hydrothermal flow capacity. This makes it possible to scale up using repeatable standardized wells, without being held back by a scarce resource and high-risk exploration. Enhanced Geothermal Systems or "EGS" also holds this promise but faces many of the same challenges as traditional geothermal; In addition, many EGS pilot projects have generated induced seismicity (earthquakes) due to the required fracking, and have subsequently been shut down. While both Closed-Loop systems and EGS are chasing the holy grail of "geothermal anywhere", Closed-Loop is much more predictable and has absolutely no fracking. A summary comparison to traditional geothermal / EGS is tabulated below.

	Traditional Geothermal or EGS	Eavor-Loop™
System design	Open System: Brine produced from reservoir, fluid exchange between system and geological formation	Closed System: Working fluid circulates in isolation from reservoir, no fluid exchange
Permeability	Traditional geothermal requires a permeable aquifer or hydrothermal source; EGS creates a reservoir through fracking.	No need for permeable reservoir or hydrothermal source.
Parasitic power load	Requires an electric pump to circulate brine continuously	Driven by thermosiphon, no pumping required
Induced Seismicity	Fracking and/or high injection pressures can lead to induced seismicity (earthquakes). EGS has long track record of causing earthquakes in EU, Asia, US.	No fracking, pressure-balanced, no induced seismicity
Greenhouse Gases	Can produce GHGs & CO2 with produced brine	No GHGs or CO2
Water Use	Continuous water use	No continuous water use
Water treatment	Continuous water treatment, scale, erosion, corrosion, produced gases, NORMs	No water treatment, simply circulating a benign working fluid
Dispatchable	Baseload, not Dispatchable	Baseload and Dispatchable, able to time-shift output while maintaining 100% capacity factor
Operating Costs	Typically greater than Capex over life of project	~80% lower than traditional geothermal
Thermal Output Uncertainty	Large initial output uncertainty prior to spending capex. Even after operating for 5 years or longer, there remains substantial risk of precipitous drop in output (revenue) due to cold water breakthrough.	Thermal output predicted accurately prior to spending capital. No thermal output risk or uncertainty.
Project Cycle Time	Typically 5-10 years or longer	~18 months, depending on regulatory regime

Table 2 - Traditional Geothermal and EGS comparison to Eavor-Loop

The technology competes in markets for district heating, cooling, and dispatchable renewable electricity. The daily output from an Eavor-Loop can be produced on a baseload basis, or time-shifted to be load-following (while still maintaining ~100% capacity factor) and, for example, produce most power during the peak and night time hours. This enables the system to integrate effectively with Wind and Solar and compete head-on with energy storage.

Deep closed-loop geothermal systems have been proposed and built before, however only at small scale. For example, several concentric Borehole Heat Exchangers (BHE) have been constructed in Europe and Japan. These concentric systems (fluid flows down the annulus then returns to surface via an insulated tubing) have ~500m of wellbore in contact with hot rock. In contrast, a commercial Eavor-Loop system has 50,000m in contact with hot rock, enabled by a) constructing a multilateral network by intersecting various wellbores and b) sealing the large multilateral section without casing.

2.3. Commercialization Strategy

Eavor's target market segments are:

- District heating or cooling in cities
- Large scale (100's of MW to GW capacity) electricity generation projects
- Distributed electricity

- Remote communities (ex: Islands or Northern Communities or regions currently generating energy with shipped or trucked-in diesel)
- Resiliency market (ex: US Department of Defense)

The initial geographic targeted markets are:

- Canada
- US
- Northern Europe
- Japan

These markets combine to be in excess of 10 GW electric equivalent and satisfy Eavor's mission to power/heat 10 million homes in 10 years.

Initial commercial Eavor-Loop™ projects are being pursued in markets with "low-hanging fruit". These markets have some combination of a history of geothermal development, predictable drilling costs, manageable logistics, large market size, high energy prices, and political and financial motivation. For example, remote communities where the fuel source being displaced is high cost (i.e. Yukon), or areas with attractive prices such as Germany. Northern Europe continues to be an area of focus for Eavor as there is also a massive heat market that enables Eavor-Loop solutions for heat or combined heat and power. Eavor is currently working on business partnerships that have a line of sight to multiple Eavor-Loop™ installations at the same project.

These geothermal "resources plays" are beneficial in several important ways:

1) Learnings from the initial loops can be quickly incorporated into the design and engineering phase of subsequent loops, allowing for transferable learnings that are directly applicable to the development area.
2) Drilling and construction can be planned to transition immediately between subsequent loops, allowing for savings on mobilization / demobilization costs and resulting in more and more experienced crews supporting each subsequent project.
3) A common surface location can be used for multiple Eavor-Loops, reducing capital expenditure for additional electricity transmission infrastructure as well as reducing ongoing operating costs of subsequent loops.
4) Ongoing technology development and continuous improvement initiatives can be deployed in subsequent loops to allow for improved financial outcomes.

Once the first commercial implementations are completed, Eavor intends to expand into broader and lower priced markets such as Alberta. The main challenges to commercialization in Alberta are a) it requires low costs to compete, given the low electricity prices and low geothermal gradient and b) lack of geothermal and distributed energy regulations. Eavor is committed to providing a competitive energy solution to Albertans and has a line of sight to supplying as much as 500 MW of electrical power.

3. Project Description

The project is located west of Sylvan Lake, near the town of Rocky Mountain House, AB, in an area with average geothermal gradient and bottom hole temperatures (Figure 3). The project comprises a U-shaped Eavor-Loop™ (Figure 1) with two vertical cased boreholes down to the Rock Creek formation, a quartz sandstone at ~2400m depth (TVD); two (2x) ~1700m horizontal multilaterals connecting these cased wells; a buried pipeline on surface to "close the loop"; and a test facility at the northern site. The vertical wells are cased and cemented in place using the standard methodology. The lateral portion is constructed with two drilling rigs operating simultaneously from both sites and intersecting the boreholes near the mid-point. The lateral portion is sealed using a chemical sealant completion system.

The surface leases are re-purposed, existing oil/gas sites (but Eavor is not repurposing any wells) owned and operated by Certus Oil and Gas. Re-use of these sites enabled a smaller footprint, lower cost design and an expedited regulatory path. The Inlet well is on the 6-1 southern site, awhile the Outlet well and surface facility is located on the 14-12 site. The pipeline also repurposed an existing Right-of-Way (ROW).

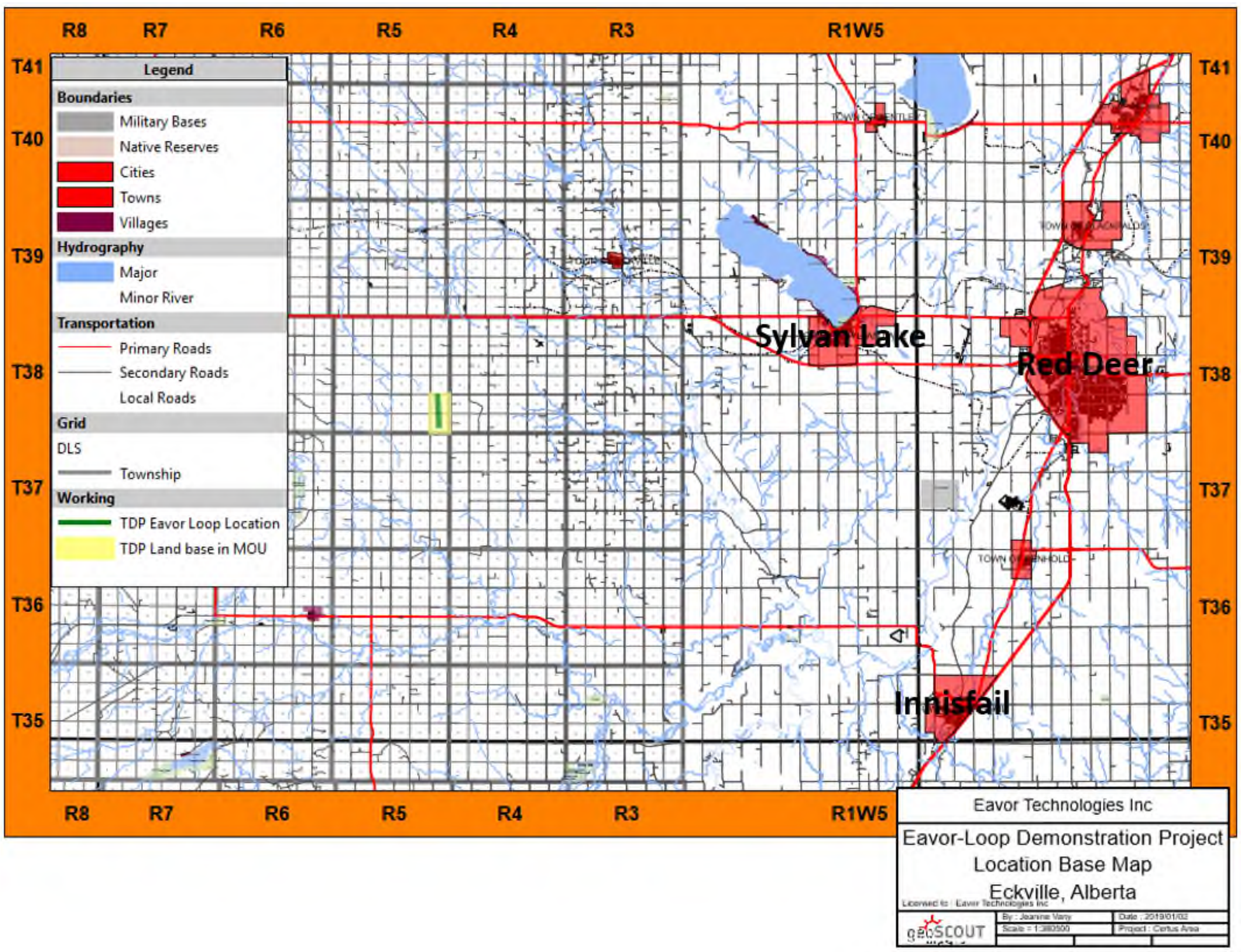


Figure 3 - Eavor-Lite Location Map

Water is circulated through the loop, powered by a thermosiphon effect driven by the density difference between the cold fluid in the inlet well (more dense) and hotter fluid in the outlet well (less dense). The circulating water is heated in the subsurface loop via conductive heat transfer, exits at surface, and the thermal energy is discharged in an aerial cooler. The layout, sealant design, multilateral junctions, multilateral wellbore intersections, and thermodynamic performance are the same as a commercial design.

Parameter	Eavor-Lite	Commercial Project
Number of Laterals	2	10-14+
Depth, TVD [m]	2400	1500 - 4500
Site-to-site distance [m]	2500	5000 (Daisy-Chain) or <100 (JamesJoyce)
Vertical casing size [in]	7	7 or 9 5/8
Multilateral wellbore size [in]	6 1/8	6 1/8 to 8 1/2
Rock Type	Quartz Sandstone	Quartz sandstone, silstone, igneous
Formation Temperature [ºC]	75	>100ºC
ΔT Inlet to Outlet well [ºC]	30	>40ºC
Multilateral completion	Rock-Pipe™	Rock-Pipe™
Multilateral Junctions	Bent sub, time drill, no whipstock	Bent sub, time drill, no whipstock
Flow rate per lateral [kg/h]	Up to 30,000	20,000 to 40,000
Lateral flowing velocity [m/s]	0.2 to 0.8	0.2 to 0.5
Facility	Storage tank, start-up circulation pump, aerial cooler, filters and throttle valve with control logic	Storage vessel, start-up circulation pump, filters and throttle valve with control logic, heat user (heat engine, district heating, etc.)

Table 3 - Comparison of Eavor-Lite to Commercial Scale

The key technical success criteria were:

Technical Objective	Success Criteria
1. Drill and intersect a multilateral Eavor-Loop with two laterals	•Successfully execute drilling program
2. Create a closed system by chemically sealing the Eavor-Loop (Rock-Pipe™ completion)	•Pressure test to 3500 kPa for 1 hour •Maintain circulation operations with < 1 m3/d leak off rate •Maintain low solids production and > 90% uptime
3. Validate thermodynamic performance and demonstrate thermosiphon	•Meet expected performance predictions based on thermodynamic modelling (history match performance) •Equates to ~900 kWth based on 2000m laterals and 18°C inlet temp •Demonstrate thermosiphon control and operation

Table 4 - Technical Success Criteria

The rationale for Eavor-Lite was to build a demonstration project that achieved the most cost-effective and quickest path to commercialization of the technology. Eavor decided on this scope after extensive consultations with potential clients and partners. The power generation component is a commercial off-the-shelf (COTS) item, has not been identified by customers as a significant commercial risk, and was therefore not included in the project scope.

4. Methodology

The project was broken into 3 milestones outlined in the original schedule below in Figure 4. The actual execution followed the plan closely, although timing was slightly different: Drilling finished in September 2019, the facility was constructed faster than planned with commissioning taking place on December 3, 2019, and operations / optimization progressed through 2020.

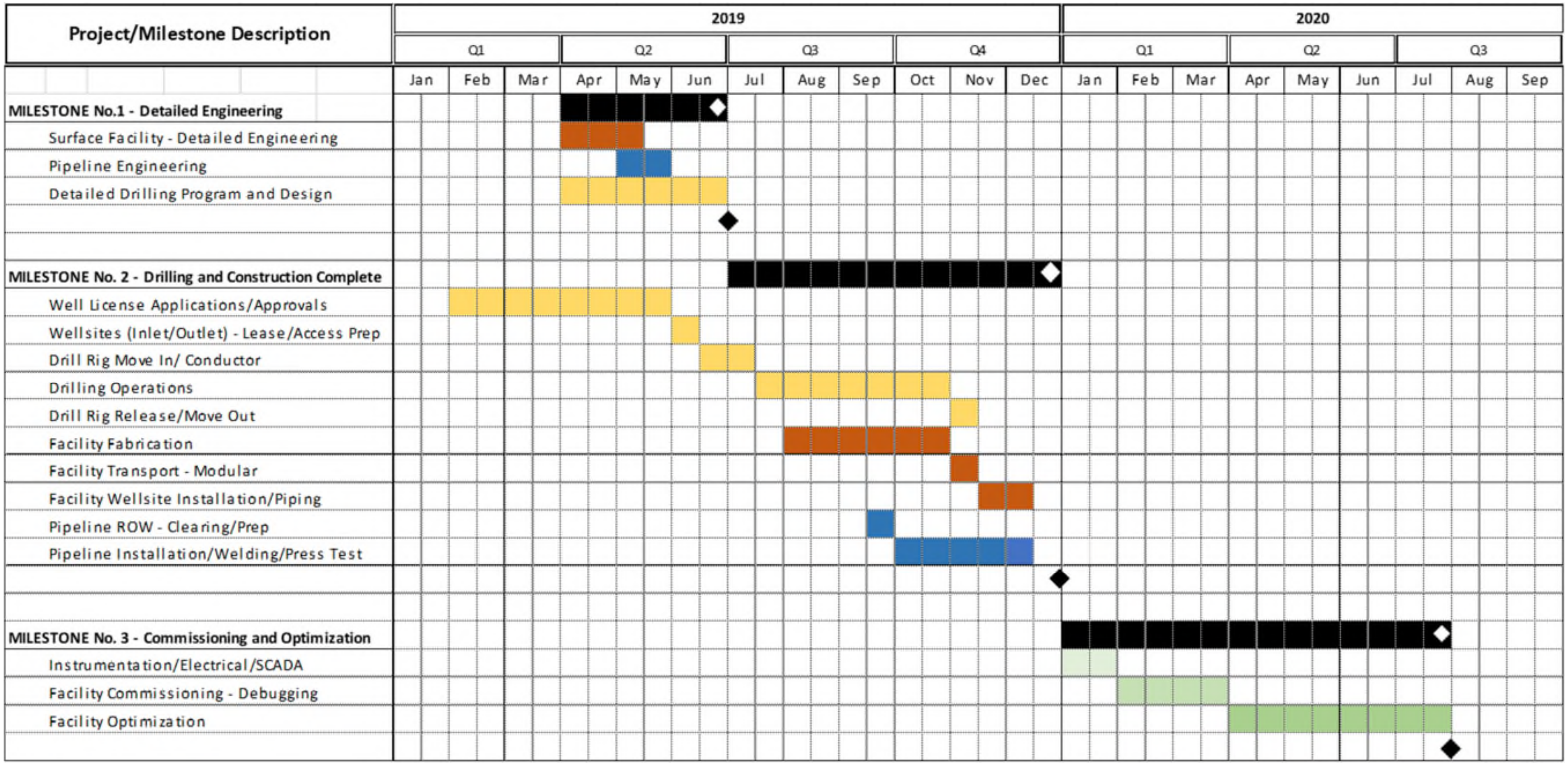


Figure 4 - Schedule and Milestones (January 2019, prior to project commencement)

A description of the methodology used to execute the project follows, broken into sections:

- Geology
- Drilling
- Surface Facilities
- Thermodynamic Validation and Operations

4.1. Geology

While rare geological formation properties suitable for traditional geothermal are not required for an Eavor-Loop, detailed geological analysis is still required. The objective is not to determine *if* the system will function but rather to properly design and optimize the project. A detailed geological assessment was carried out in Milestone 1, and summarized below.

4.1.1. *Stratigraphy and formation temperature*

The Rock Creek Member of the Fernie formation is considered a nearshore marine sand as evidenced by the trace fossils found therein (Losert, 1986). Typical log signatures have a blocky signature and sharp base and exhibit slightly coarsening upward signatures typical of sheet sands (Figures 7&8). Geological mapping shows the average gross thickness across the horizontal wells is 15 m and the structure ranges between -1407 m subsea to -1389.2 m subsea (Figures 5A & 5B respectively).

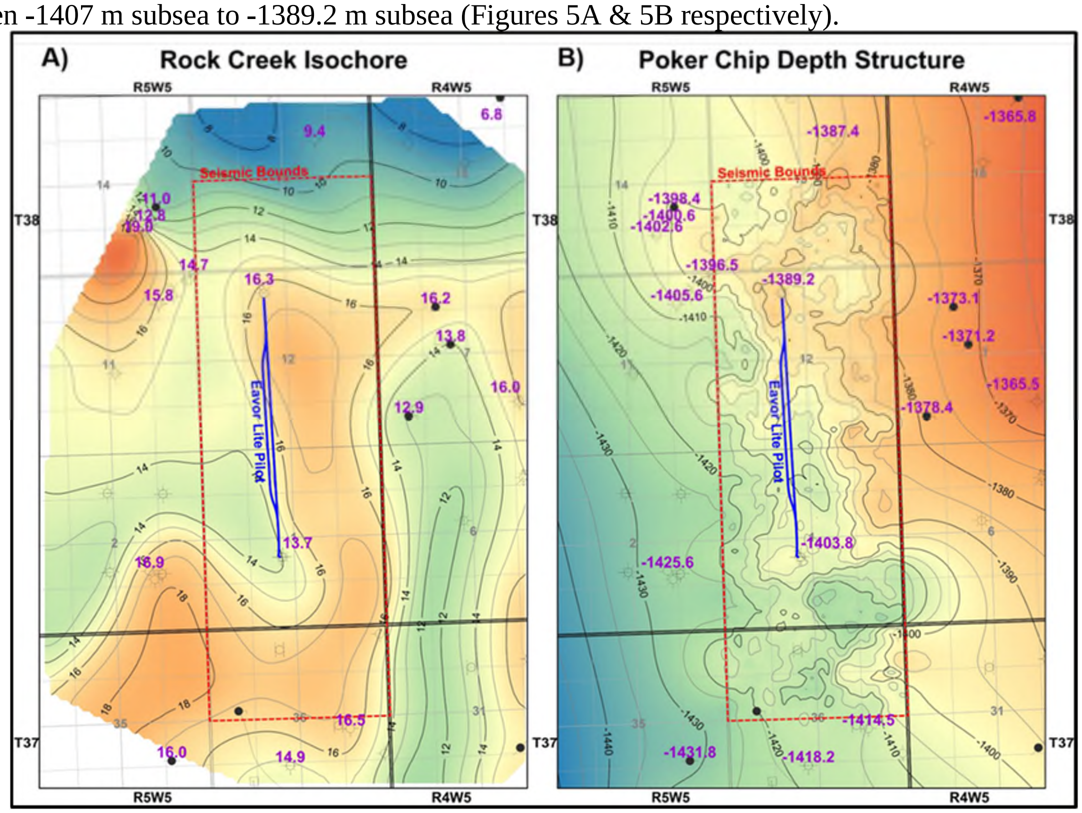


Figure 5 - A) Rock Creek gross sand isochore and B) depth structure map on the top of the Poker Chip Formation (base of Rock Creek formation)

The geothermal gradient in the area is 30 degrees Celsius per km therefore the expected temperature in the Rock Creek using an ambient temperature of 6 degrees Celsius is approximately 76 degrees Celsius. Various nearby wells were used to confirm the expected formation temperature, and corrected for systemic errors such as drilling cooling.

4.1.2. *Rock Characterization Data and Methods*

As Eavor-Lite is in an area of active hydrocarbon development there is abundant raw data and literature to draw from. It was important to further characterize the Rock Creek for Eavor-Loop™ implementation and to establish a baseline, primarily for thermodynamic modelling. Therefore, a series of core tests for further rock characterization was completed including; thin sections, X-Ray diffraction (XRD) and unconfined compressive strength. The two wells on the existing sites, 100/14-12-038-05W5/00 and 100/06-01-038-05W5/00 did not have core over the zone of interest. Two cores were chosen for sampling, 100/11-28-038-05W5/00 and 100/08-30-037-03W5/00, located approximately 6 km NW of the project and approximately 11 km ESE of the project respectively. The following sampling program was undertaken:

Test Type	Measurement	Objectives
Triaxial testing	Measure the stress state of the rock creek and determine the maximum compressive strength of the rock	Ground truth Eavor Lite geomechanical hypothesis prior to drilling to validate mud weights
Thermal conductivity	Determine the thermal conductivity of the Rock Creek	Populate Eavor Lite thermodynamic model prior to drilling, calibrate Eavor Lite model post drilling by comparing to actual thermal output
XRD	Detailed mineralogical analysis	To back calculate thermal conductivity and determine if mineralogy could substitute thermal conductivity measurement in the future
Thin sections	Petrographic Study	Determine cementation to aid rate of penetration modelling, understand controls on porosity and permeability

Table 5 - Objectives of the rock characterization core study

Only the results relevant to thermodynamic modelling are summarized below.

The regional results of the core data for porosity and permeability are summarized on probit plots (Figure 6). The core porosity from the regional probit plot (Figure 6A) suggests a P50 of 7 % for the Rock Creek, and a range in data from 2% to 28% porosity. Core permeability from the regional probit plot (Figure 6B) shows a P50 of 0.57 mD and range in data from 0.01 to 108 mD.

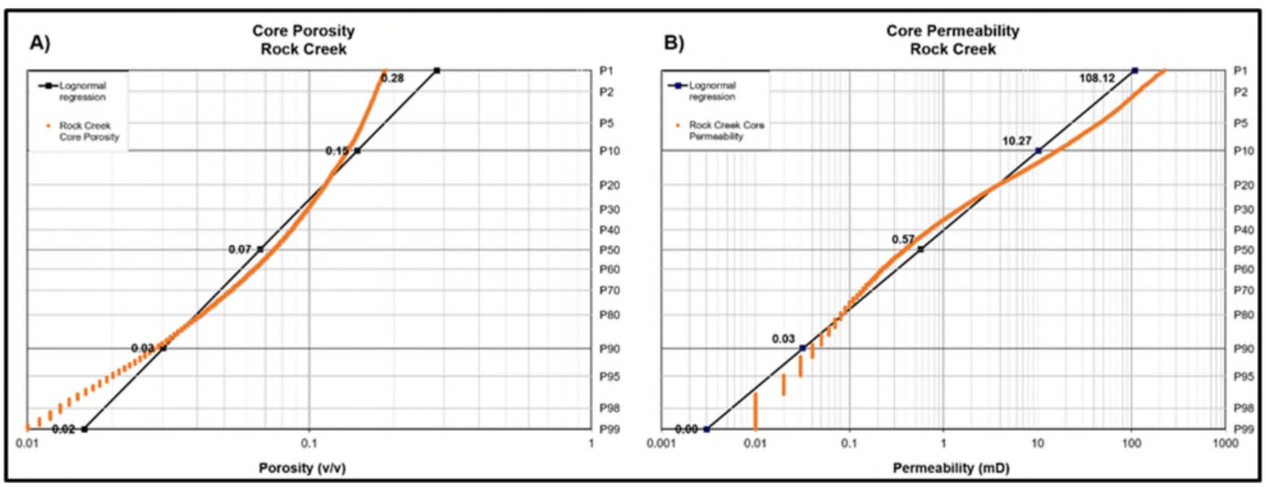


Figure 6 – Rock Creek Regional Porosity Probit Plot and B) Regional Permeability Probit

Two vertical wells penetrate the Rock Creek and are the control wells for the planned TDP; 100/14-12-038-05W5 and 100/06-01-038-05W5. The 100/06-01-038-05W5/00 well (Figure 7) has a full curve suite including gamma ray, neutron/density porosity, sonic and resistivity and the 100/14-12-038-05W5/00

(Figure 8) has gamma ray, sonic and resistivity enabling a robust petrophysical analysis to be completed in both wells.

The porosity for the 100/06-01-038-05W5/00 well was calculated using a neutron-density cross plot. The porosity in the 100/14-12-038-05W5/00 well was calculated using the sonic log and the Wyllie time average equation. Total porosities were corrected for shale using a volume of shale calculated from gamma ray log with a linear conversion to obtain an effective porosity. Water saturations were calculated using the simandoux equation with A, M and N constants of 0.62, 2.15 and 2.0 respectively, and a water resistivity of 0.14 ohm*m at 25ºC which was obtained from nearby water analysis. A porosity cut off of 3% was applied to the Rock Creek to obtain an average porosity.

The average porosity for 100/06-01-038-05W5/00 and 100/14-12-038-05W5/00 is 8.1% and 6.4% respectively.

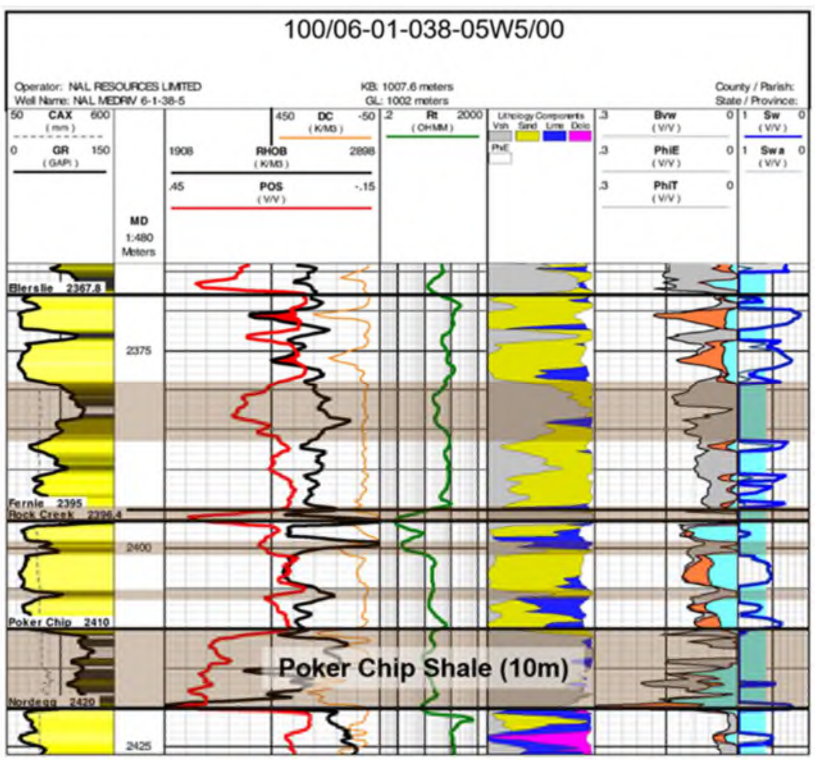


Figure 7 - 100/06-01-038-05W5/00 Type Log with petrophysical interpretation

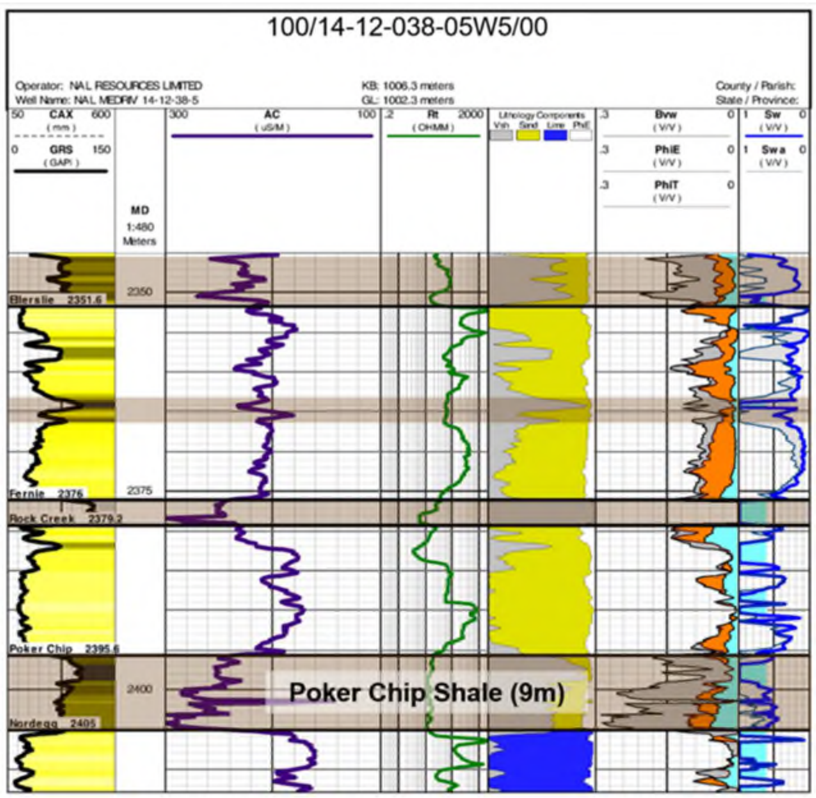


Figure 8: 100/14-12-038-05W5/00 Type Log with petrophysical interpretation.

4.1.3. *X Ray Diffraction and Thermal Conductivity Modelling*

The results of the bulk XRD reveal both cores are quartz based with percentages ranging between 31.4% to 94%. Three of the 4 samples have samples with > 70% quartz. The XRD agreed with the general interpretation that the Rock Creek Member is a quartzarenite sandstone, however bulk mineralogy shows that samples in the 100/11-28-038-04W5/00 well are remarkably different in that the quartz percentage is 31.4% compared to 72.2% in the shallower sample. Calcite makes up most of the bulk sample with percentages ranging between 0.3% to 62.1% (Table 6).

UWI	Sample (m)	Quartz	Feldspar		Carbonates		Clays	Sulphide
			Albite	K-Feldspar	Calcite	Fe-Dolomite	Illite/Mica	Pyrite
100/08-30-037-03W5/00	2242.5	93.3	1.8	1.5	0.7	0.4	1.9	0.3
100/08-30-037-03W5/00	2249.3	94.0	1.3	0.9	0.3	0.0	2.0	1.4
100/11-28-038-05W5/00	2423.1	72.2	1.6	2.2	19.0	0.3	3.8	1.0
100/11-28-038-05W5/00	2428.7	31.4	0.9	1.2	62.1	0.5	2.1	1.8

Table 6 - XRD Bulk Mineralogical Results

In order to estimate thermal conductivity from mineralogy a simple analytical model was adopted from Jorand et al. (2015). The model used XRD and petrophysical data to calculate volume percentage of minerals and total porosity of the rock. The thermal conductivity was calculated by weight averaging the thermal conductivity of the fluid and the matrix, which was determined with a power equation weighting the volume fractions of the minerals present. The thermal conductivity was corrected to temperature by scaling the temperature dependant results presented in Jorand et al., 2015 and Robertson, 1988. A further

0.9x factor was multiplied to account for large scale heterogeneity of the rock such as lithology changes, shale plugs, fractures with different mineralogy, organic matter etc., and small-scale errors such as grain to grain contacts, cementation and grain size distribution. Using an average reservoir temperature of 75 degrees Celsius, the model calculated an average thermal conductivity for all 4 samples to be 4.5 W/mK. The predicted average rock thermal conductivity for the 100/08-30-037-03W5/00 and 100/11-28-038-05W5/00 is 4.7 and 4.3 W/mK respectively. Quartz has a very high thermal conductivity, approximately 7 W/mK at reservoir temperature (Robertson 1988). Although, the quartz percentage drops to 31% at 100/11-28-038-055/00 well, the predicted average thermal conductivity is relatively unchanged (4.7 W/mK compared to 4.3 W/mK). This is due to the decrease in porosity, which has an inverse relationship to conductivity. Therefore, although porosity degrades from south to north along the horizontals, the thermal conductivity remains relatively stable. This thermal conductivity estimate is the key input into predicting thermal output.

4.2. Drilling

Drilling of the Eavor-Lite project used standard equipment and methodologies except for 2 items which were new: intersecting multilateral wellbores with magnetic ranging technology and sealing them with the Rock-Pipe™ chemical completion system (rather than using steel casing).

A wellbore directional schematic is shown in Figure 9 for the North rig, and a stick diagram shown in Figure 10. The corresponding figures for the southern rig are similar. Both drilling rigs were supplied by Precision drilling, who partnered on the project with Eavor.

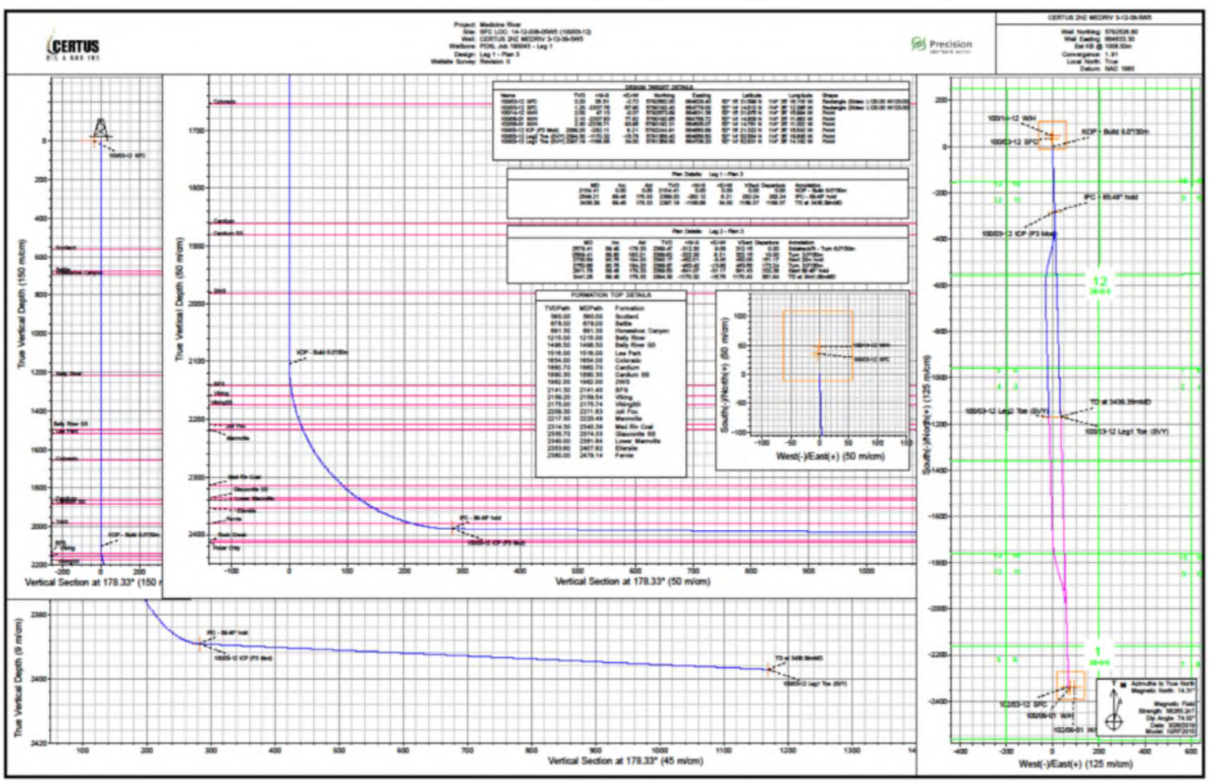


Figure 9 - 14-12 HZ 100/03-12-038-05W5M Directional Plan

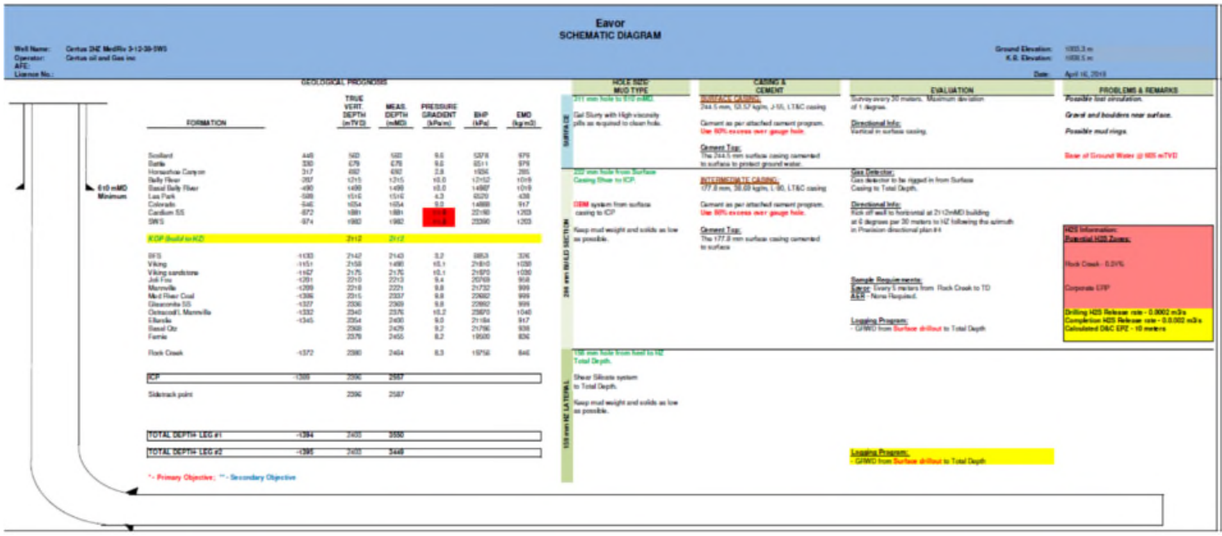


Figure 10 - 14-12 HZ 100/03-12-038-05W5M Stick Diagram

4.2.1. *Wellbore Intersections*

The Bottom Hole Assembly (BHA) from both rigs had magnetic ranging tools installed once they were within ~100m of each other. The target wellbore contains a receiver, and the subject well utilizes a magnetic solenoid emitter tool. The magnetic tools have sufficient accuracy to “home-in” on the target well and appropriately steer for intersection. Magnetic ranging equipment is commonplace in Alberta and has been used on over 4500 Steam Assisted Gravity Drainage wells in the oilsands industry. While intersection is not a typical operation in oil/gas, it uses standard magnetic ranging and control technology, and has been performed for various applications over the years. This is the first time to our knowledge it has been used to create a multilateral closed-loop geothermal network.

Prior to detection range of the magnetic tools, the ellipse of uncertainty of each well’s position is minimized. Figure 11 below shows the ellipse of uncertainty in blue using a Gyro run to refusal (almost horizontal) and in-field referencing, compared to standard operations in green. As long as the ellipse of uncertainty for both wells are within the range of the magnetic ranging tools, the magnetic tools detect the relative distance and direction and enable appropriate steering to complete the intersection.

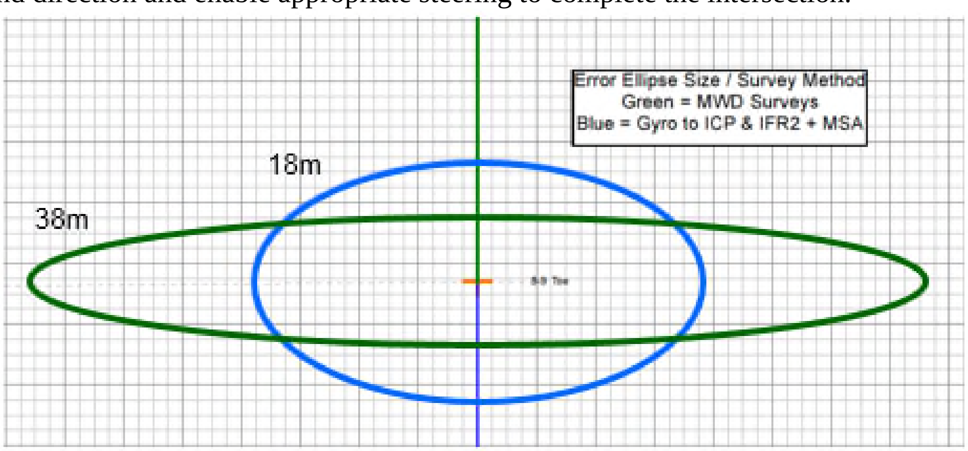


Figure 11 - Ellipse of Uncertainty for intersections

4.2.2. *Rock-Pipe™ Completion System*

Eavor worked in conjunction with Shear Fluids and other firms to develop a specific drilling fluid system designed to seal the near wellbore porosity / permeability, called Rock-Pipe™ completion system. The technical function of the drilling fluid is different in porous rocks (for example sandstone) relative to shale (Figure 12). In porous formations such as sandstone (which we are drilling in the Demonstration Project), it is not a thin film which is deposited on the interior face of the wellbore. Rather, the sealant penetrates into the pore space and natural fractures within the rock itself before "setting" into a solid. The sealant is filling in the 10% porosity that is within the rock itself. The material properties are largely derived from the rock (90% rock, 10% sealant).

In contrast, in rocks with near zero permeability such as shale, the function is not to seal off permeability – the rock already has none. Instead, the function of the drilling fluid is to provide a mechanical/chemical barrier between the shale and wellbore and to fill-in any natural fractures.

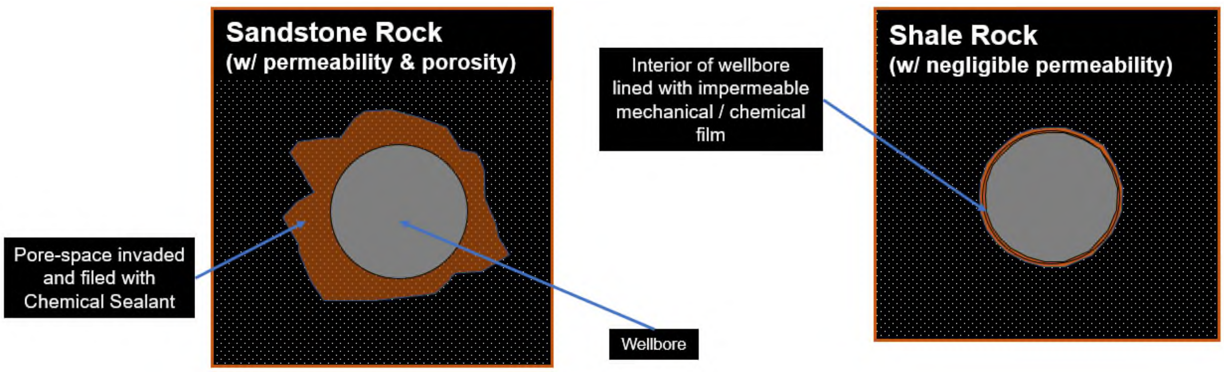


Figure 12 - Illustration of Rock-Pipe completion system in different formations

4.3. Surface Facilities

The Surface Facilities for the project are illustrated in the Process Flow Diagram shown in Figure 13. The outlet well site (14-12) facilities consists of a water storage tank, solids removal, centrifugal pump, and aerial cooler. The hot water from the outlet well, which has been heated downhole, enters a water storage tank to drop out solids and manage volume changes (thermal expansion and subsurface leak-off). The water is circulated by thermosiphon or centrifugal pump and cooled in a forced draft aerial cooler with a variable frequency drive on the fan motor to control the outlet water temperature. The water flows into a buried pipeline and returns to the inlet well to be re-injected downhole to be re-heated. The water is initially trucked into the water storage tank to fill the loop, and corrosion inhibitor, well integrity additives, and drag reducing agents are added in a batch treatment. The hydrostatic head due to the water level in the tank also sets the pressure at the inlet to the circulation pump.

The flow rate of water through this closed loop system is measured and controlled by a magnetic flow meter downstream of the outlet well. The thermosiphon is initiated with the circulation pump; the flow controller opens the minimum flow recycle back to the tank to maintain a minimum flow through the pump. Once flow is established, the recycle valve closes and the flow rate through the loop is controlled by the main control valve downstream of the outlet well. A thermosiphon effect is generated by the density difference between colder (higher density) water flowing to the inlet well relative to the hotter water (lower density) returning from the outlet well. The pump is turned off and bypassed during thermosiphon mode. The main control valve downstream of the outlet well is used to set the thermosiphon flow rate.

There are multiple transmitters to measure the pressure and temperature at the outlet well, the inlet to the pipeline and the inlet well. Flow meters on the outlet and inlet wells, in addition to redundant radar level transmitters on the water storage will be utilized to measure any loss or gain of water through the closed loop system. This information will be used to quantify loss/gain of water to the sub-surface formation.
Overall the surface facility will have a relatively small footprint, and there will be no flaring, no venting and no ground water usage / disposal requirements. Electrical power will be required to operate the centrifugal pump, aerial cooler fans, instrumentation, and heat tracing on the outdoor piping and to prevent freezing when the ambient temperature drops below zero.

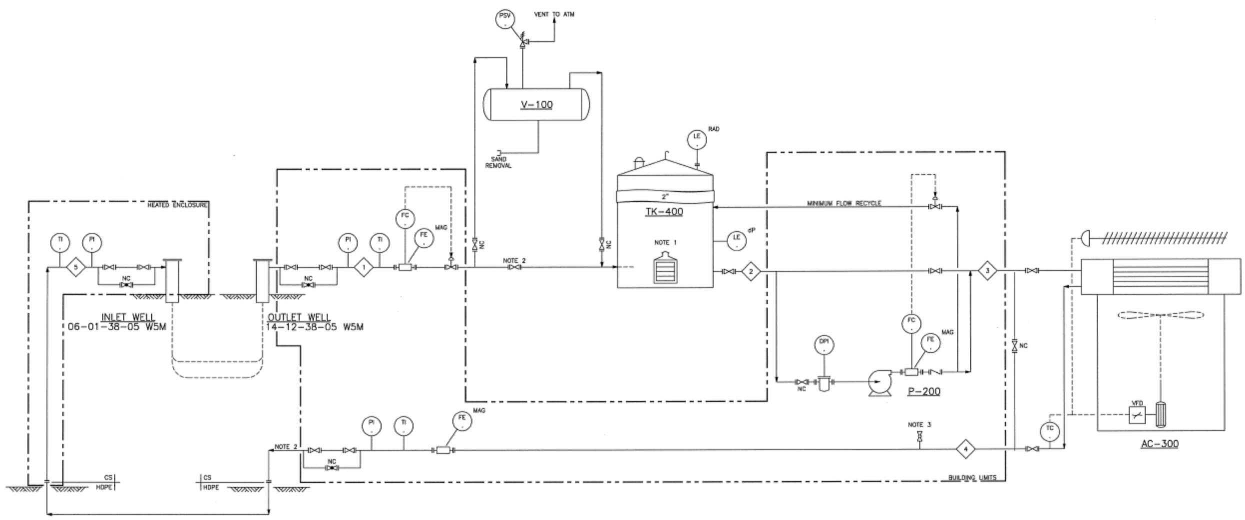


Figure 13 - Facilities Process Flow Diagram

4.4. Thermodynamic Validation and Operations

Eavor™ has used three approaches of increasing complexity to predict the thermal output of Eavor-Lite: an analytical equation, a transient 2-dimensional model, and a 3-dimensional computational fluid dynamics model. For operational projects, the best approach is to use a transient numerical wellbore model in radial coordinates. The advantages of this type of model are the quick computational run-time, relative simplicity, and ability to handle transient data such as shut-in periods, changing flow rate and inlet temperature, and variable fluid properties.

Eavor has built an in-house version of this model which can automatically load empirical data from the field SCADA system. Further, the model utilizes an automated history matching algorithm to update predicted output.

The momentum and energy equations for water flow in the horizontal well bore can be solved along with the algebraic equations for transient heat conduction in a coupled solution method to predict how the pressure and temperature of the water flow in the well bore changes over time. In a steady-state scenario without variable input parameters, the transient numerical approach aligns almost exactly with the analytical approach of Ramey, 1962, and Kutun, 2015. The key input parameters in the modelling are rock temperature, fluid flow rate, chemistry, inlet pressure, inlet temperature, and thermal conductivity of the rock, *k*. Thermal conductivity has been estimated using the mineralogy approach described in section 4.1. Thermal conductivity is the key history matching parameter once empirical field data is collected.

In a commercial design with 10+ multilaterals, no insulation is required in the outlet well to achieve high thermal efficiency. However, at the smaller scale of Eavor-Lite and with only 2 laterals, significant heat losses are realized in the vertical outlet well. Rather than install an unnecessary and expensive Vacuum Insulated Tubing, the team opted instead to measure the flowing temperature profile in the vertical outlet well – this provides enough information to validate the thermodynamic model. Hence, 6 thermocouples are installed in a 3/8" stainless steel instrument string in the outlet well, evenly spaced from 2000m MD to surface.

The temperature distribution of the rock using fixed operational parameters is illustrated after 1 year of circulating operations in Figure 14 and 5 years in Figure 15, with radial distance on the y-axis, axial position along a single lateral on the x-axis, and temperature represented with the color bar.

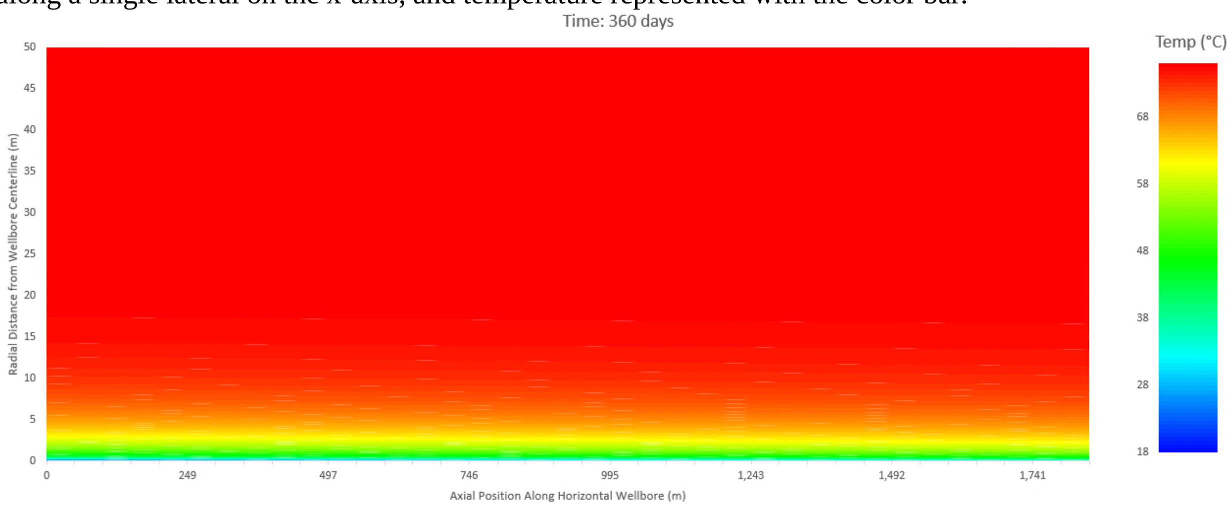


Figure 14 - Eavor-Lite Rock Temperature model after 1 year operations

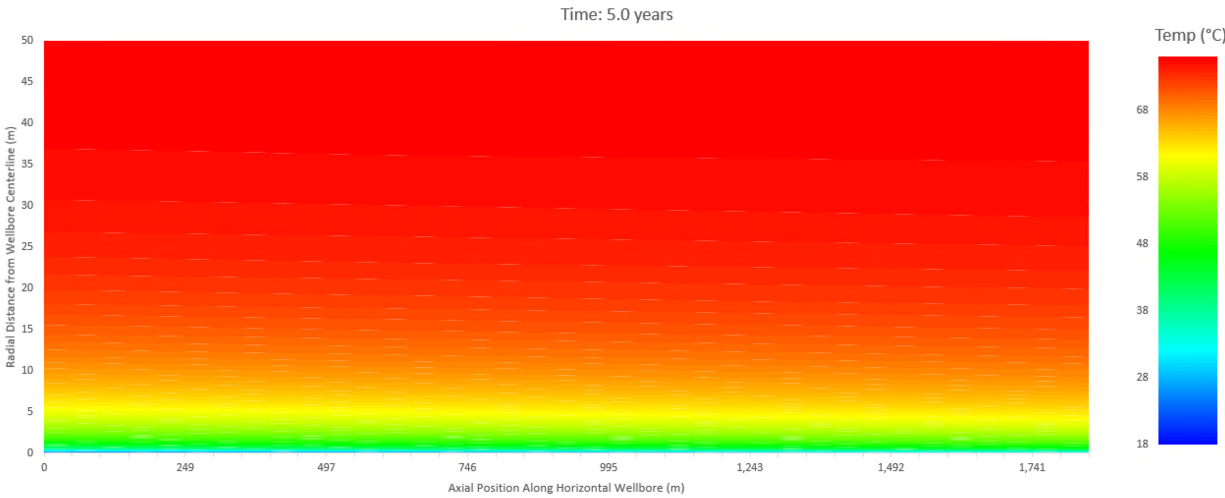


Figure 15 - Eavor-Lite Rock Temperature model after 5 years operations

In practice, the inlet well parameters of the project are variable due to commissioning issues, ambient temperature fluctuation, flow rate selection, and various research and testing programs. Hence, true validation of the thermodynamic model requires inputting a time-series of inlet well fluid conditions (flow rate, temperature, pressure) and comparing the calculated outlet parameters with measured data. The prediction of the outlet temperature is directly tied to the amount of thermal or electrical energy that the Eavor-Loop can produce.

The main disadvantage of the model is that it cannot calculate the long-term effect of thermal interference between the laterals. However, the Eavor-Lite project is only expected to run for 5 years, prior to any significant interference between the laterals. Using Fluent Computational Fluid Dynamics (CFD) software from ANSYS, a full 3D simulation of the system has been performed. The results show an exact match with the radial numerical model until the wellbores begin to interfere with each other after approximately 6 years. Therefore, CFD is useful for designing and estimating performance for commercial projects with a 30+ year operational life, but not necessary to predict and history match Eavor-Lite.

4.4.1. *Working Fluid*

The base design working fluid consists of fresh water, corrosion inhibitor, biocide, and small amounts of silicate and other additives to promote long term integrity of the RockPipe™, i.e. the horizontal sections. The system was initially commissioned on water with biocide and corrosion inhibitor, with small amounts of silicate added to the system after ~ 6 months of operation to test the impacts on the overall system.

A further iteration working fluid consists of fresh water, corrosion inhibitor, anti-freeze, shale inhibitor, and surfactant-based drag reducing agents (DRAs). This chemistry has been developed at the University of Alberta (UofA) Turbulent Flow Laboratory since September 2018. Unlike the off-the-shelf DRAs common in the oil industry, Eavor-Loop™ requires re-circulating DRAs which recombine after high shear events (pumps, heat exchangers, etc.). These are not commercially available products and the chemistry needs to be properly designed and integrated with all the other additives. Lab results show an average 60-66% turbulent drag reduction compared to pure water over the temperature range required for heat applications (Figure 16). The Figure shows performance from several different chemistries, the best selection depends on the temperature range of the loop. Formulations have also been developed at UofA for higher temperature electricity applications.

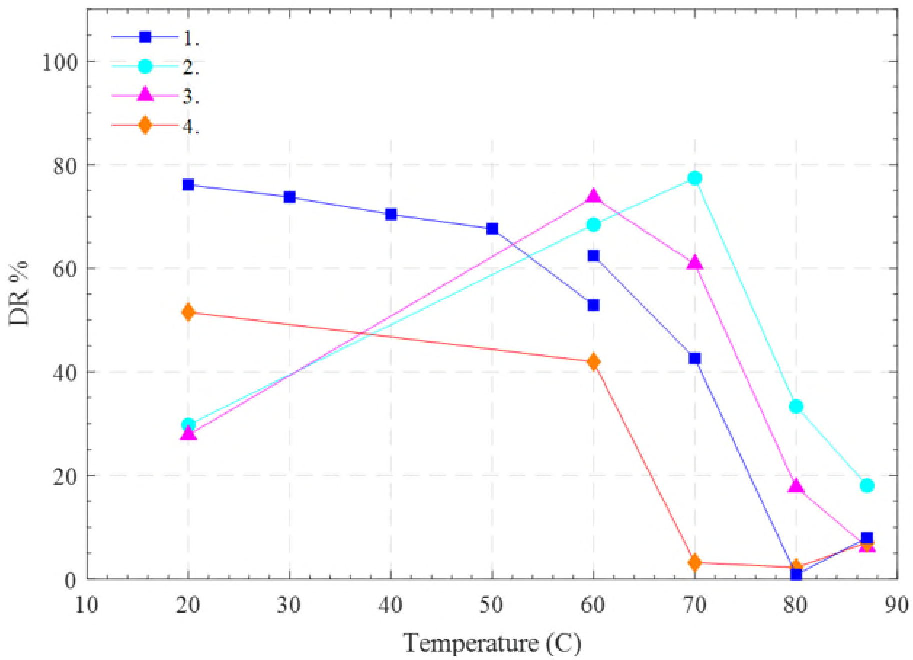


Figure 16 - Drag Reduction test data from UofA

4.4.2. *Operations*

Eavor-Lite is operated remotely using an automated control system (Figure 17). After commissioning with a pump on December 3rd, 2019, the loop was switched to thermosiphon mode on December 4th, 2019. The flow rate is automatically controlled by a control choke and flow meter at the outlet well. Temperatures, pressures, fluid chemistry and leak-off rate are monitored continuously. Various flow rates, temperatures, and other parameters were tested to understand system performance.

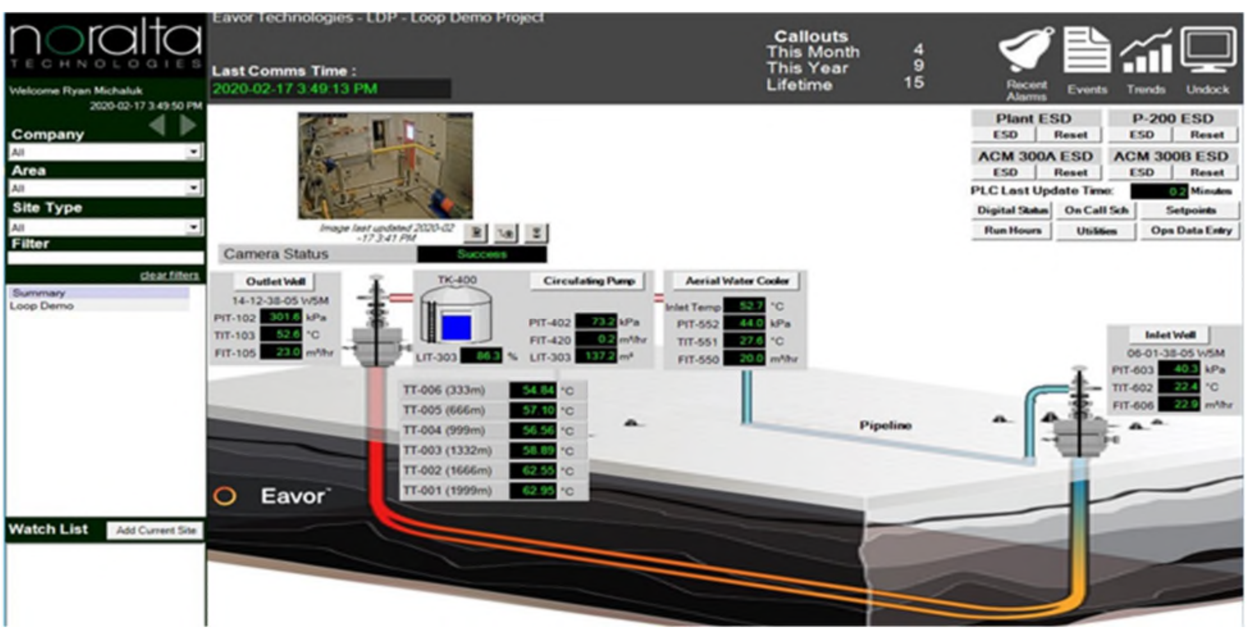


Figure 17 - Eavor-Lite Control Dashboard (screenshot)

5. Project Results

The project was generally executed according to plan - on schedule, on budget, and all technical objectives were achieved. Timeline and key dates are displayed in Figure 18.

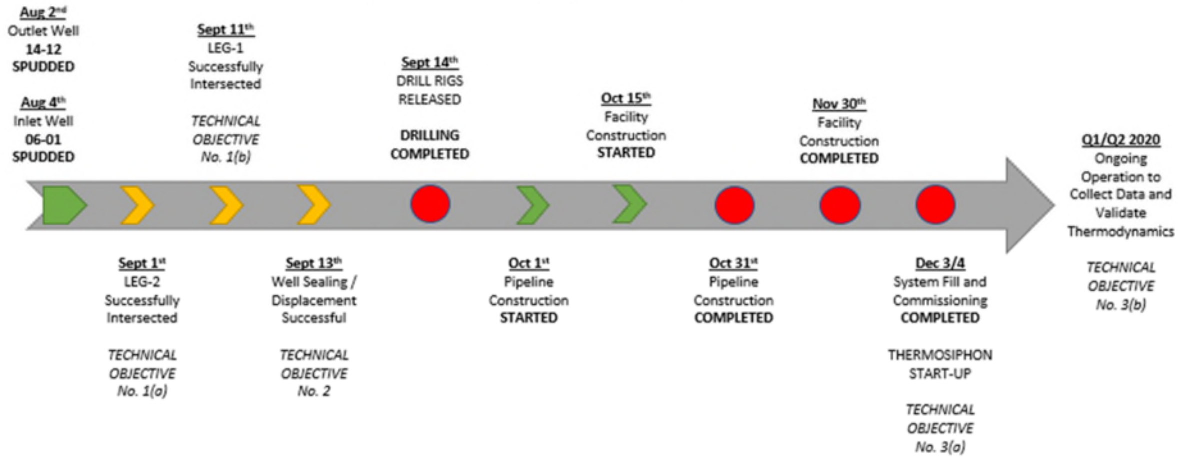


Figure 18 - Eavor-Lite Actual Timeline

5.1. Geoscience

The vertical section was drilled without events, and all geological tops came in generally as expected. Figure 19 shows the vertical directional profile of 100/03-12-038-05W5/00 (14-12 north site) actuals compared to plan. The primary geological target was the Rock Creek Formation, which was encountered at a measured depth of 2480.00m from 14-12 site (True Vertical Depth 2380.20m, Subsea -1371.20m).

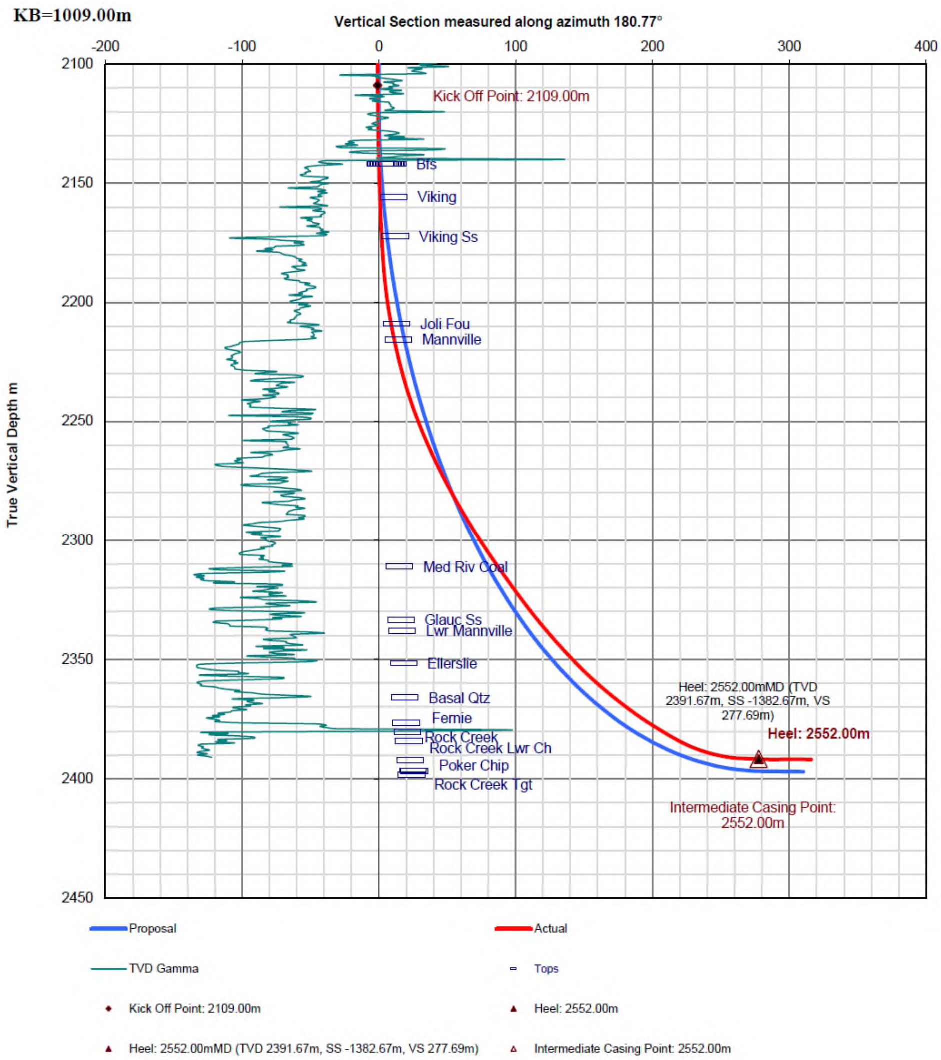


Figure 19 – 14-12 (north well) vertical section Actual vs Planned

The Rock Creek, as observed in samples, consisted primarily of light brown, grey brown, clear to translucent, upper very fine to lower medium grained, moderately well to well cemented quartzarenite. Pervasive calcareous cement was primarily observed, however clean siliceous cemented samples with trace calcareous cements, were also encountered. The Rock Creek sandstones in the Lower Channel section were also observed to contain common bioclasts(shell fragments), while grading in sections to arenaceous limestone, and bioclastic limestone. Porosity estimates were primarily tight to poor intergranular (2-6%), with occasional fair (6-10%) porosity. Minor visible light brown stain was noted, with hydrocarbon shows varying from poor to good. Total gas responses up to 750 units (9x background) were observed. Gamma counts ranged from 10 to 45 API.

The well was geo-steered with support from wellsite geologists on behalf of Chinook Consulting Services. Real-time geo-steering software was used to update the geological model based on MWD Gamma logging and cuttings samples. Despite the relatively thin zone and structure, all multilateral wells were maintained within the Rock Creek section. Estimates of the structural elevation of the formation derived from 3D seismic in the planning phase proved to be quite accurate. Figure 20 shows the estimated horizontal wellbore position within the Rock Creek zone.

Figure 21 shows the horizontal portion of 102/03-12-038-05W5/00 (southern site) Actual profile vs. Planned, for Leg #2. Note that the south rig drilled faster than the north rig, resulting in the intersection point being replanned past the mid-point between both sites.

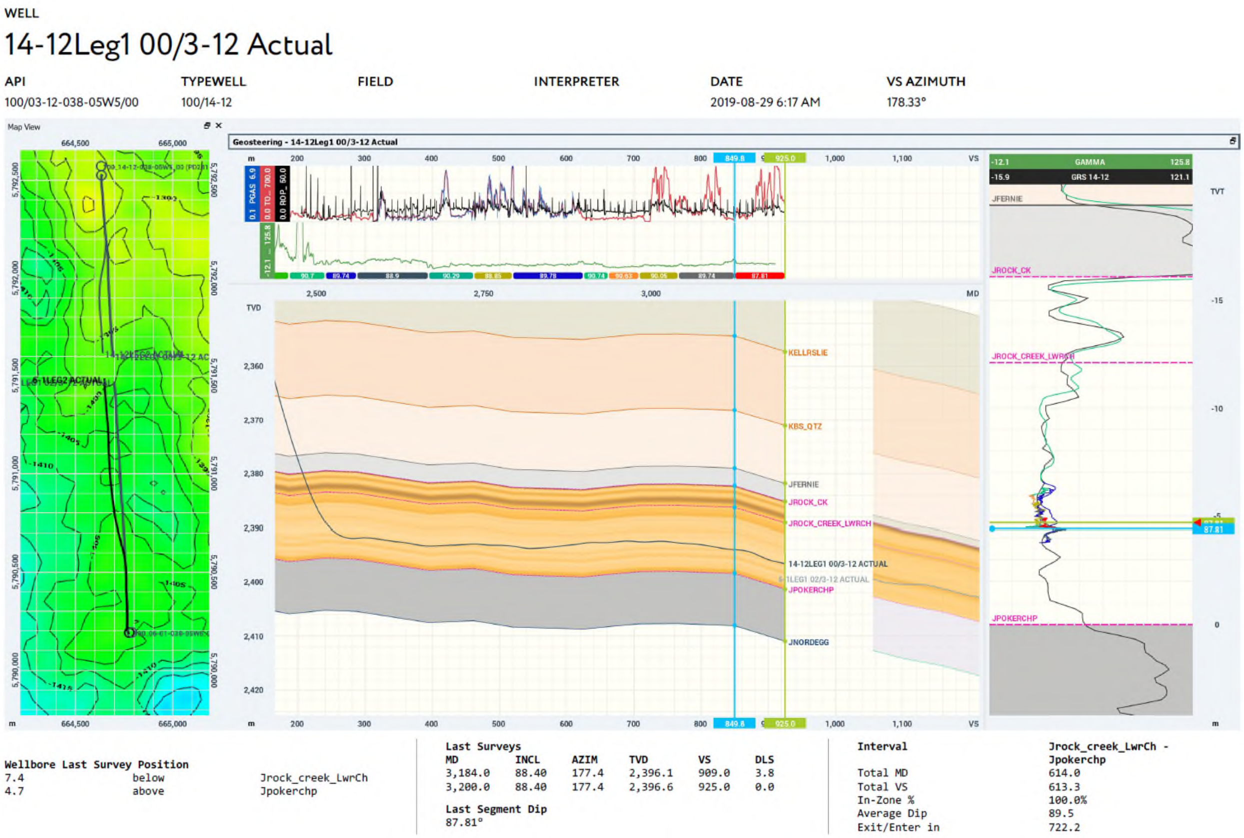


Figure 20 - 14-12 Leg #1 Actual geological summary

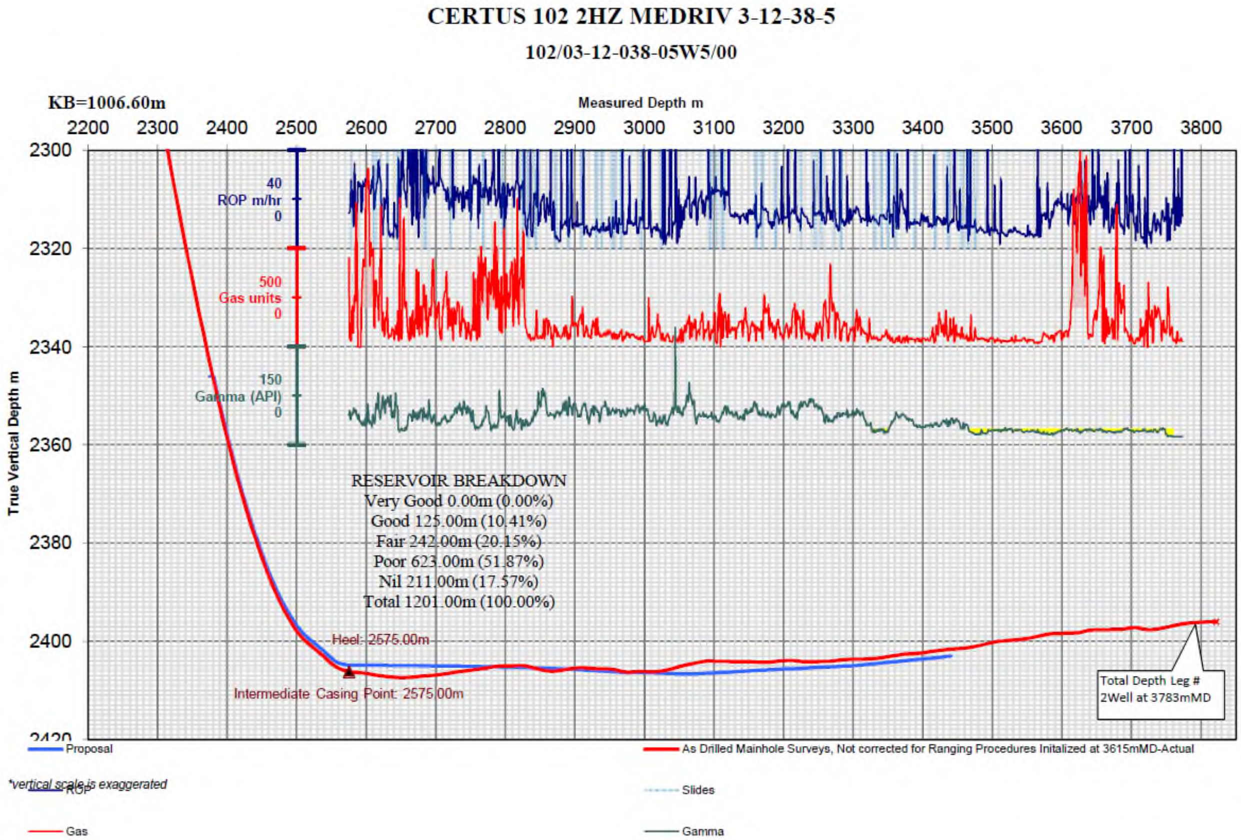


Figure 21 - 06-01 (South Well) horizontal section Actual vs. Planned

5.2. Drilling

The initial technical objective was to successfully design, plan and execute the drilling program to connect two multilateral legs with two drilling rigs operating simultaneously from surface locations 2.5 km apart. The innovative elements of the technology include drilling from two rigs simultaneously and achieving intersection of multiple 6 1/8" wellbores using magnetic ranging technology at 2.4 km depth and 1.25 km horizontal distance from the intersection point.

Precision Drilling rig PD 231 drilled from the 14-12 North site, and rig PD 241 drilled from the 06-01 southern site. The wells were spud on August 2, 2019 and August 4, 2019, respectively. Both the Precision Drilling rigs were released on September 14, 2019 after approx. 43 consecutive days of incident-free drilling operations. A total of 8.8 kms of new borehole was drilled to construct the sub-surface segment of this demonstration loop.

5.2.1. *Wellbore Intersections*

Both complex LEG-1 and LEG-2 wellbore intersections were successfully achieved by PD Rig #241 on Sept 1 and Sept 11, 2019 respectively.

LEG-1: On Sept. 1, 2019 we successfully executed the world's first of its kind 'toe-to-toe' horizontal wellbore intersection on the opposing LEG-1 laterals. Hydraulic communication and intersection were achieved 0.5m earlier than our ranging prognosis at 3,678.32m(MD). After intersecting, we reamed into the target wellbore 50+ meters taking measurements while drilling (MWD) surveys throughout to further verify mechanical intersection. Wellbore ranging operations were executed flawlessly on this LEG-1 segment, yielding an approximate 83% cross-sectional coverage of the toe of the target wellbore. See Figure 22 below where the target well (14-12) is shown in 'green' and the intersecting wellbore (06-01) is shown in 'blue'.

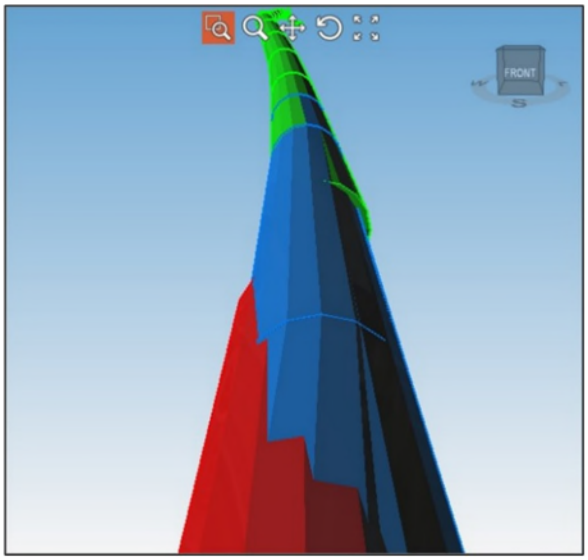


Figure 22 - Leg-1 Intersection Sept. 1, 2019

LEG-2: The intersection operation for LEG-2 presented various new challenges and subsequent learnings. Unlike the previous LEG-1 Intersection, the drill bit was positioned 0.31m left and 0.16m below the target well at the intended intersection point. As a result, we passed under the target well ultimately intersecting at a low convergence angle (4°) roughly 83m laterally back from the toe of the target well.

This LEG-2 intersection occurred at 3,783.11m(MD) on Sept. 11, 2019. See Figure 23 below where the target well (14-12) is shown in 'red' and the intersecting wellbore (06-01) in 'blue'.

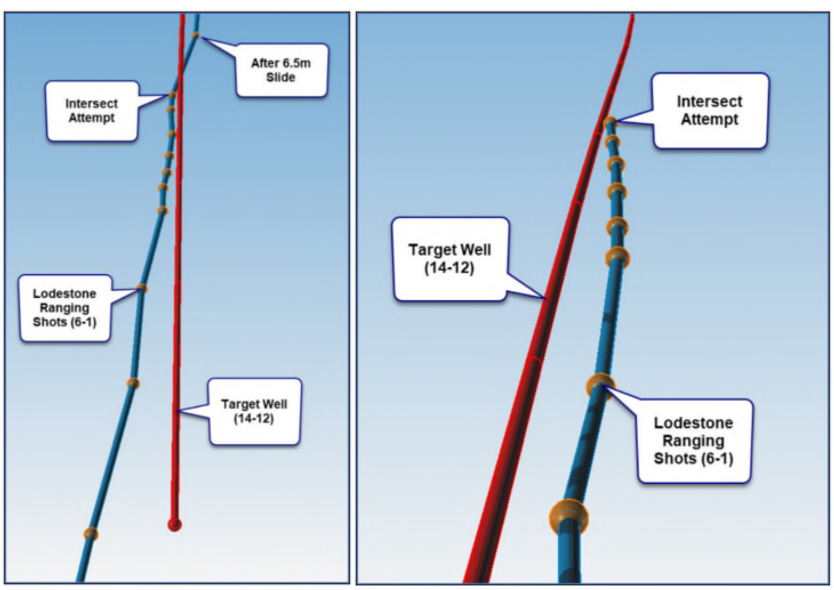


Figure 23 - Leg-2 Intersection Sept. 11, 2019

Figure 25 shows the Final As-Drilled Schematic.

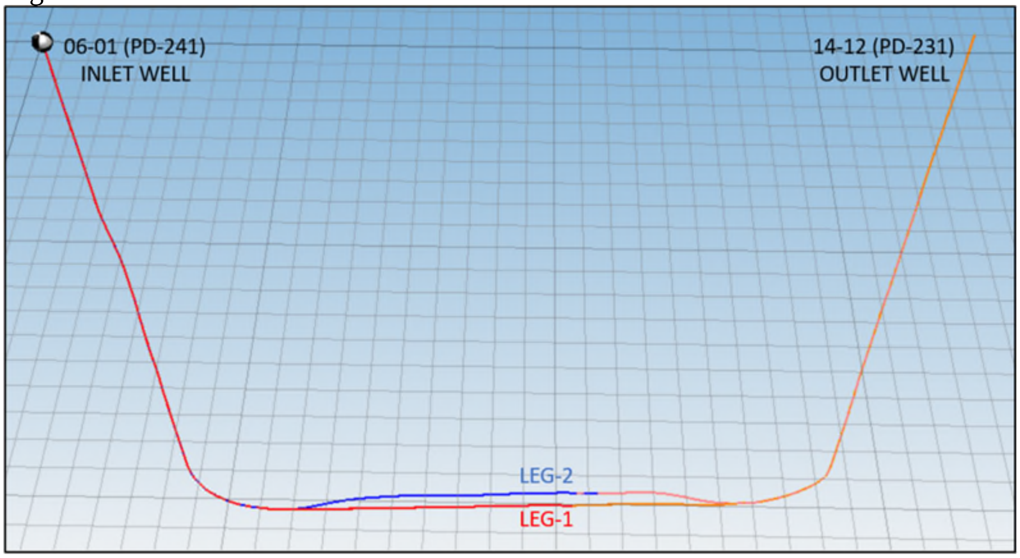


Figure 24 - As-Drilled Final Directional Profile

5.2.1. *Wellbore Sealing*

The second unique element employed in the Eavor-Lite™ project was the ability to chemically seal the horizontal lateral wellbore while drilling. Eavor's specialized silicate-based mud system was utilized across all 3,597m of open-hole lateral sections. This horizontal 156mm diameter section(s) represents approx. 41% of the total sub-surface drill meterage.

The sealing effectiveness was monitored and validated during drilling operations based on negligible mud losses. Formation integrity tests (FITs) were also carried out at specified intervals throughout the drilling program to test the effectiveness of the sealant through application of 5 MPa pressure (measured at surface) for a period of 15-75 minutes per test. These FITs were carried out systematically to validate the near-term sealing integrity of the wellbores on nine separate occasions at various intervals as horizontal drilling progressed, including tests pre-intersection, following the initial intersection, and following completion of both intersections and drilling fluid displacement.

A summary of the FIT data is summarized in Table 3 below. In the below table, all measurements were taken pre-intersection with the exception of the final two tests: PDI-241 test at 3,680 mMD was performed upon completion of the initial LEG-1 intersection, while the final PDI-241 test was performed upon completion of both intersections and following displacement of the drilling fluid.

PDI-231 (14-12)				
Test Depth [mMD]	**Lateral Leg**	**Initial Pressure [kPag]**	**Final Pressure [kPag]**	**ΔPressure [kPad]**
3027	2	5127	5055	-72
3188	2	5135	4986	-149
2929	1	4929	4900	-29
3200	1	5000	4820	-180
PDI-241 (06-01)				
Test Depth [mMD]	**Lateral Leg**	**Initial Pressure [kPag]**	**Final Pressure [kPag]**	**ΔPressure [kPad]**
3006	2	5045	3980	-1065
3045	1	5149	4430	-719
3550	1	6005	5189	-816
3680	1 (INT)	5154	4590	-564
Post Displacement	1&2	5454	5322	-132

Table 7 - Eavor-Lite Formation Integrity Test Data

As can be seen from the data presented in the table above, the change in pressure progressively decreased with subsequent FITs – most notably on the PDI-241 rig where the initial pressure losses were higher. The decline in these losses over subsequent tests supports the sealing mechanism working properly in that the sealant solidifies over time. Note that the length of open wellbore more than tripled from the first FIT on 06-01 to the final post-displacement FIT, yet the pressure-drop declined from 1065 kPa to 132 kPa.

The higher pressure-drop at 06-01 is also due to a higher permeability formation on the 06-01 inlet well (PDI-241). The higher initial losses are indicative of a larger volume of the sealant chemistry permeating into the near wellbore. This downward trend in pressure loss is expected based on the geological properties and sealing chemistry.

Overall, the completed system was able to maintain 97.5% of the applied 5 MPa pressure. During Eavor-Lite operation, the surface pressure is <0.1 MPa.

In addition to the FITs, the initial sealing integrity was further validated upon execution of the Post-Drilling Mud-Displacement program. The full volume of this drilling mud (218 m3) was displaced from the entire loop with the working fluid without any apparent losses to the formation. Eavor developed and implemented a dual verification method for this mud displacement exercise; (i) viscous dye pill spacer for visual confirmation; (ii) real-time pH analyzer for higher resolution chemical composition verification. The initial displacement return was pumped from 06-01 and received at 14-12 within four (4) minutes of the calculated 174 minute displacement pumping duration, indicating that the subsurface wellbore geometry is consistent with the expected geometry given the bit dimensions and measured distances, and the flow split between the two lateral legs is approximately equal.

Following start-up of the system on December 4, 2019, samples were taken of the outlet well produced fluid (upstream of the water storage tank) as well as downstream of the aerial cooler to visually assess any solids production. There was no evidence of solids in the samples. Solids production is also monitored by measuring the pressure drop across the filter upstream of the circulation pump. During the commissioning phase on December 3, 2019, no change to this dP was observed while the pump was operational.

Another key parameter that continues to be monitored is the sub-surface leak off rate of the system. A working fluid additive trial was performed in April, and a full sealant augmentation trial was performed in July, both indicating positive impacts to reducing the steady state leak off rate. The steady state leak-off rate in Q1 2020 was ~ 0.75 m^3/d. Following the silicate trial in April, the leak off slowly trended down to ~ 0.45 m^3/d in June. Following the full system augmentation and resumption of steady state operation, the steady state leak off rate for Aug / Sept 2020 was ~ 0.41 m^3/d.

The leak off is below the 1 m^3/d target and continues to trend down over time. We are continuing to investigate options to further reduce the sub-surface leak off as much as possible.

5.3. Surface Facilities

The Eavor-Lite Facility and pipeline were built ahead of time although slightly over budget. An interactive 3D virtual tour is available on www.eavor.com which describes the system and how it works. Figure 25 shows a picture during commissioning on December 3, 2019.

Figure 25 - Eavor-Lite Facility picture

5.4. Thermodynamic Validation and Operations

The third technical objective of this demonstration project was to confirm the thermodynamic performance of the Eavor-Loop™ closed loop geothermal process. Eavor has developed in house simulation software to model the energy transfer from the rock to the working fluid and has validated this software with operational data. This includes demonstrating the thermosiphon effect.

5.4.1. *Thermosiphon Demonstration*

The switch to thermosiphon mode was done on December 4, 2019, following the fluid fill and system commissioning that was completed on December 3-4. The system had been operating for ~ 24 hours using the circulation pump while system commissioning was being completed. The final step in commissioning was to test the emergency shut down (ESD) functionality of the system, which would shut off the pump, isolate and drain the aerial cooler, and close the main flow valves to stop circulation.

The ESD test was performed on December 4, 2019, at 11:15 AM. The system remained offline with no circulation for a period of approximately 20 minutes while the auto drain sequence on the aerial cooler was tested. Following completion of this test, the main flow valves were re-opened to see if the thermosiphon could reestablish circulation. Over the course of 5 minutes, the flow gradually increased to the set point flow rate of 35 m^3/h, at which point the throttling valve on the outlet well began to close to maintain the desired flow. This data is shown in Figure 26, with the pump discharge pressure shown in 'blue' and the circulation rate shown in 'orange'.

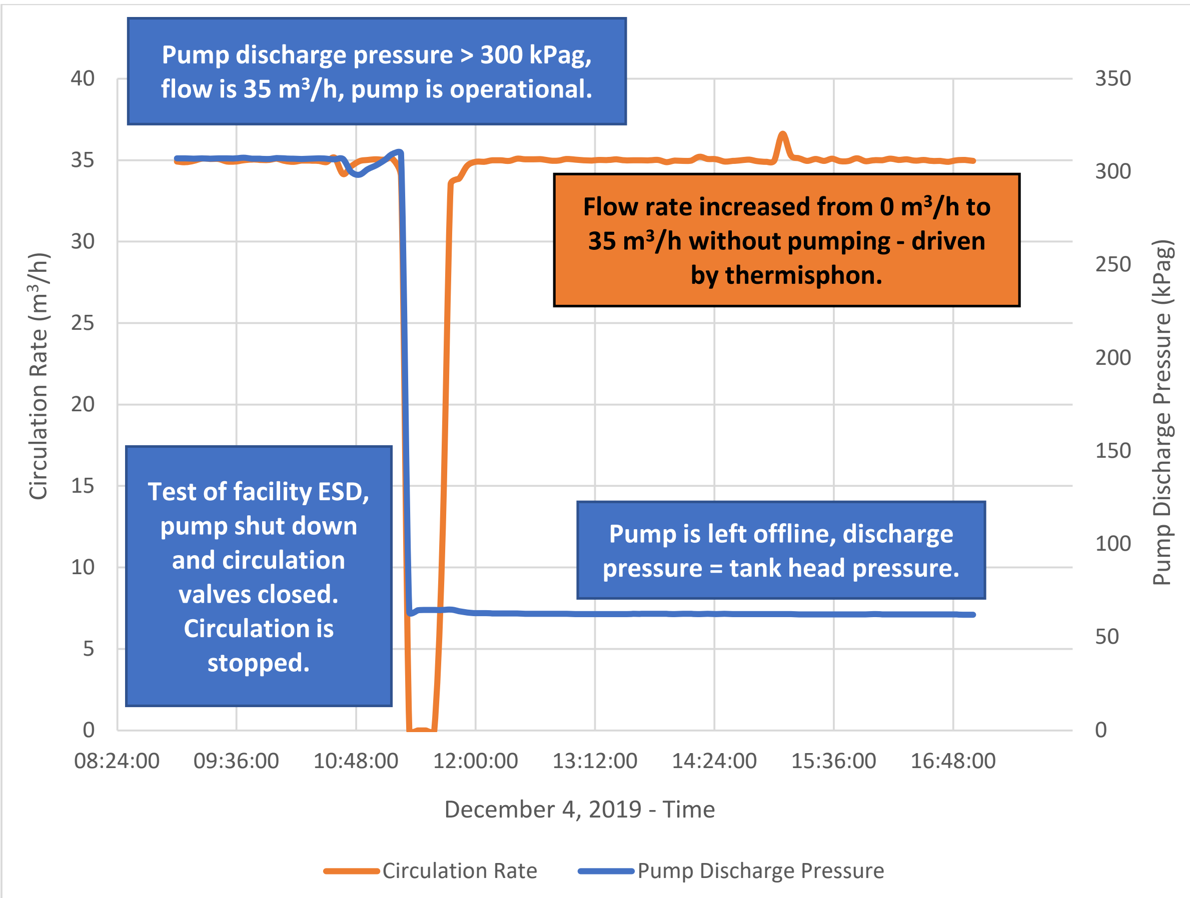


Figure 26 - Eavor-Lite thermosiphon start-up

Overall, this test successfully proved the ability of the thermosiphon to start up an Eavor-Loop™ system without the use of a circulating pump within 1 day of operation. The facility has been stable and operating consistently in thermosiphon mode since December 4, other than ~10 days with the pump for various testing.

5.4.2. *Thermodynamic Validation*

The thermodynamic performance of the Eavor-Lite project is being measured and compared to the simulated performance calculated using thermodynamic modelling software. Data has been collected since start-up on December 3, which is then imported into this transient model. The key input parameters for the model are the inlet well pressure, temperature, flow rate, rock temperature and rock thermal conductivity. Using these parameters, the outlet temperature and pressure of the system are calculated numerically by closing the energy and momentum equations for each discretized segment of the Eavor-Loop vertical and lateral wellbores.

Validating the model involves generating a "history match" of the empirical field results using the model, then forecasting that model forward to predict future performance. A good history match is obtained if the model accurately predicts measured values.

The initial project performance was estimated using the rock thermal conductivity of 4.5 W/mK outlined in section 4.1.3. Since all the rest of the parameters are known with high confidence, rock thermal conductivity is the degree of freedom, or history match parameter which is varied to obtain a good history match. An excellent history match was obtained after 60 days of operations. The best match was obtained using a thermal conductivity value of 4.64 W/ m K, very close to the original estimate. This is an excellent result which shows that output of an Eavor-Loop can be predicted very accurately prior to spending capital.

History Matching	Pre-Spud estimates	History Matched	Data Range Used	Error
Horizontal Thermal Conductivity [W/mK]	4.5	4.64	Dec 4, 2019 - Feb 2, 2020	-3%
Vertical Thermal Conductivity [W/mK]	2	2.25	Dec 4, 2019 - Feb 2, 2020	-11%

Table 8 - History match thermal conductivity

Figure 27 shows the results of this history match model when it is used to forecast performance. The parameters are fixed to the history matched values as of Feb 2, 2020, except for the variable operational parameters such as inlet temp, pressure, and flow rate. The thermodynamic model has been validated, with the measured outlet temperature continuing to align within <2% of the simulated results over the operating period. The model is accurate even over most transient events except for fast, short lived shutdowns or with external factors (such as new fluids being introduced externally) – example is on April 25th.

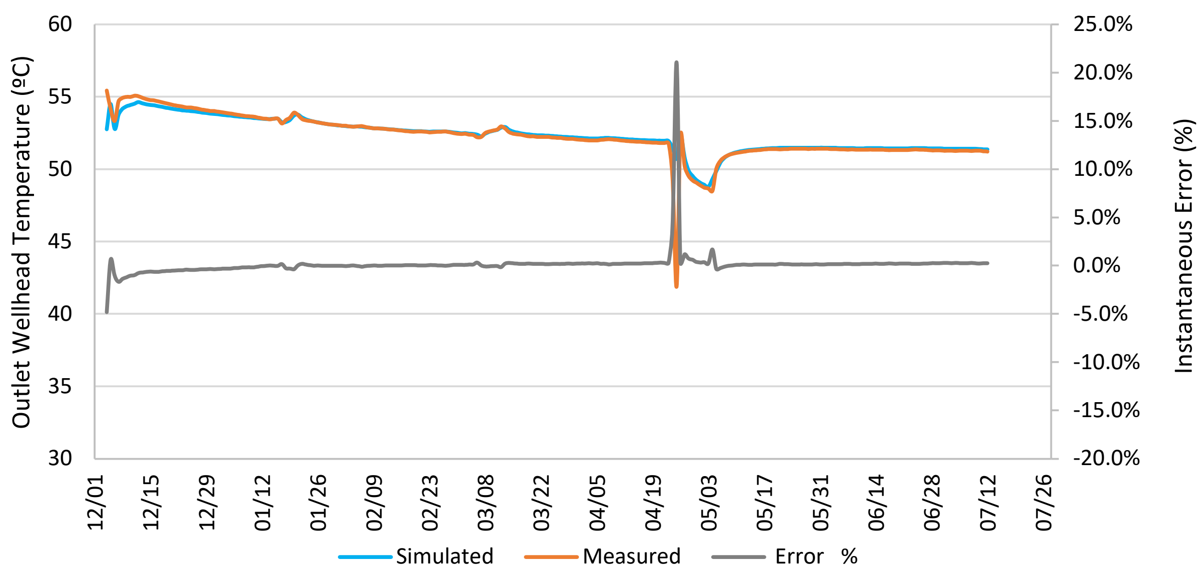


Figure 27 - Simulated vs. measured temperature

A test was performed on February 19, 2020, where circulation was stopped by closing the main flow valves for a period of 15 mins. After the 15-minute period, the valve was re-opened, and the thermosiphon was able to re-establish circulation in < 5 minutes without any assistance from the pump. This test has been repeated several subsequent times to demonstrate the black start capabilities of the facilities, most recently in October 2020 where the facility was shut down for a period of 14 days (Sept 22 to Oct 6) to test the regeneration rate of temperature in the rock for additional thermodynamic model validation under transient conditions, with the thermosiphon able to re-establish flow after this period with no pump requirement.

Eavor also engaged TNO, a third-party research organization based in the Netherlands, to do an independent validation of the Eavor-Lite thermodynamic results. TNO used an independent analytical approach and confirmed the accuracy of the thermodynamic results that Eavor simulated. A key chart (Figure 30) and excerpt from TNO's final report is shown below:

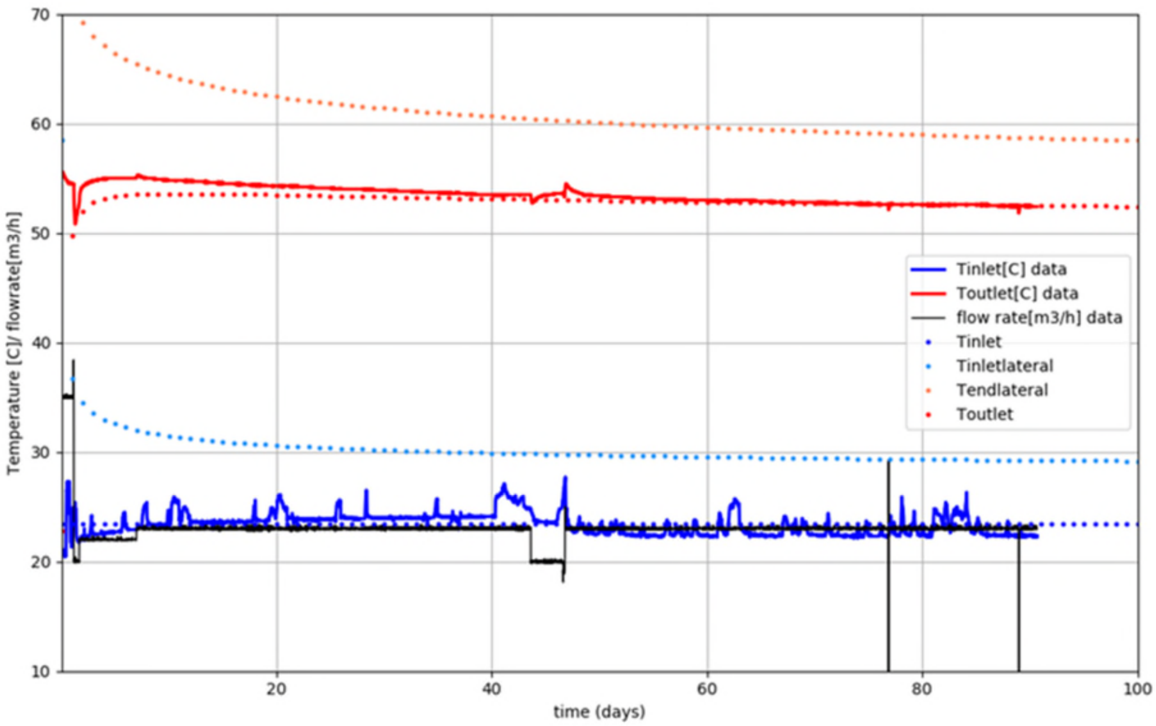


Figure 28 – excerpt chart from TNO audit of Eavor-Lite, measured (red line) and simulated (red dots)

"TNO applied its independent analytical model (section 2) to evaluate the Eavor Loop demonstration outcomes… …The aim was to determine if the measured outlet temperature given the flow rate and inlet temperature is consistent with the Eavor Lite loop well layout, ambient rock properties and reservoir temperature… …The Eavor Loop Lite demonstration shows production temperatures which are consistent with analytical model prediction, marked by an excellent correspondence of prediction and observations after 30 days."

An overall summary of the Eavor-Lite technical objectives is shown below.

5.5. Summary of Technical Objectives

Technical Objective	STATUS	Summary of Results
1. Drill and intersect a multilateral Eavor-Loop with two laterals	✓	LEG-2 was successfully intersected on September 1, 2019
	✓	LEG-1 was successfully intersected on September 11, 2019
	✓	Drilling program was completed and rigs were demobilized on September 14, 2019.
2. Create a closed system by chemically sealing the Eavor-Loop (Rock-Pipe™ completion)	✓	9 x formation integrity tests to 5 MPa performed throughout drilling and upon completion of drilling program with > 97.5% of pressure maintained.
	✓	Current operation leak off rate is < 1 m3/d.
	✓	Visual samples and filter differential pressure monitoring indicating negligible solids production, facility has been running at ~95% uptime since Dec 4, 2019 start-up.
3. Validate thermodynamic performance and demonstrate thermosiphon	✓	Thermosiphon has been fully operational, ongoing circulation without use of pump since Dec 4, 2019 start-up.
	✓	Preliminary thermodynamic model validation has been completed with measured performance within 2% of predicted (over first year operations).
	✓	Ongoing data collection and validation to prove out simulation capability over longer time frame. Third party validation of preliminary results received in August 2020.

6. Key Learnings

Key learnings from the drilling, surface facility and operations components of the project are discussed below. The learnings for the operational drilling can be segregated into (i) Project Specific and (ii) Project Non-Specific. The latter takes priority in terms of advancing and applying improvements and optimization methodology to future commercial projects. Learnings associated with Eavor-Lite regarding geology in the Rock Creek Formation, bit performance relative to these formation characteristics and variable rate of penetration (ROP) at each well dipole are unique/non-transferable and as such have not been catalogued here.

6.1. Drilling

6.1.1. *General Drilling*

(a) **Casing Wear** – not an issue for Eavor-Lite specifically, however, larger commercial projects will require additional rigor in the casing design and the use of wear bushings may be warranted in these cases.

(b) **Hydraulic Isolation** – it became evident that hydraulic isolation (temporary) after the first well intersection will reduce drilling flat-time by allowing the rigs to not have to stand-by while the other rig completes a task, estimate a reduction of approx. 2-3 days of rig time could have resulted with some form of temporary isolation. Larger rig elevation differences will make this even more important. Full attention and communication between rigs was essential in this regard.

(c) **Sidetracks** – sidetracks for second lateral(s) were drilled successfully and works quite well. Biggest learning was with the re-entry operations. Further optimization for successful re-entry of drill string/Bottom Hole Assembly (BHA) will require careful monitoring of pump rate and BHA orientation. Minor changes to the BHA on the PD241 side made re-entry operations marginally more difficult. There is room for significant improvement by utilizing identical BHA configurations for consistent and repeatable re-entry operations.

6.1.2. *Wellbore Intersection*

(a) **Conveyance** – ranging receiver pumped down drill string on static well side needs to have proper synchronization between wireline operator and rig pumps. Improved communication on this will further reduce mechanical risk on getting tool to bottom and ultimately reducing pump down frequency and drill curve flat time.

(b) **BHA Positioning/Tool Selection -** overall the ranging operations worked well, opportunity for further improvement lies with positioning of the ranging tool as close as possible to the bottom-hole of the target well as possible. Additionally, near bit sensors should be considered to further increase confidence in ranging projections to the bit. Premature pull-back of ranging tool inside the target well diminishes accuracy. In hindsight, the pull-backs were driven by concerns regarding BHA 'collision' at intersection points. In future, consideration should be given for potential interference impact of ferrous additions to the BHA.

(c) **Gyroscopic Surveys** – running gyro tool at each intermediate casing point (ICP) proved helpful as this calibrates the MWD positioning for improved resolution near the intersection points at pre-intersection total depths (PITD).

6.1.3. *Initial Rock-Pipe™ completion method*

(a) **Mud Displacement -** execution and results were as expected. The logistics associated with the displaced mud-system regarding storage, disposal and lease spacing requirements were definite learnings in terms of spatial requirements for surface tanks required for this operation. In future, initial planning stages will need to account for acquisition of additional space for displacement tankage. Using a tracer during the displacement to estimate distribution among the laterals was an effective technique.

6.2. Surface Facilities

(a) **Storage Tank Head Limitations –** the project was designed to incorporate a water storage tank that is open to atmosphere. This decision was made from a cost perspective to eliminate the need to design to a higher-pressure specification, and to eliminate the auxiliary nitrogen system that would be required to blanket the tank and maintain pressure. However, in practice, relying on the head provided solely by the tank level required the flow rate to be reduced significantly to ensure that there is always positive pressure on the inlet well (downstream of the pipeline). This introduced some limitations in operating the facility. Note that the whole system was designed to introduce a very low pressure drop while circulating, but the learnings around pipeline design outlined in the next bullet point compounded this issue.

(b) **Pipeline Design –** Rangeland Engineering was accountable for the pipeline design and construction but outsourced elements of the engineering of the pipeline to a third party (Strategic). Rangeland was accountable for the hydraulic calculations on the pipeline, resulting in a large diameter pipeline (10") to be selected for our application to maintain a low pressure drop through the 2.5 km line. During the engineering, confirmation of the elevations of the inlet and outlet well were made to ensure that there was no incremental pressure loss due to the system flowing towards a higher elevation. It was found from the surveys that the outlet well was ~1m higher in elevation than the inlet well, which helped with the hydraulics.

However, during the construction it was identified that the actual profile along the right of way (ROW) wasn't clearly communicated (i.e. assumption was that this was a 'flat' farmers field) and there was ~ 8 m of elevation gain from the 14-12 surface location to the high point along the ROW. This elevation profile has created challenges in operations, notably that we have introduced slack flow to the system (flow instability due to the large change in elevation) and have reduced the flowing area of the pipeline due to air trapped at the high point. This effect has resulted in higher than calculated pressure loss through the pipeline.

While the facility was designed to operate from 20-50 m^3/h, the practical upper limit during thermosiphon operation while limited by the available pressure generated by the tank head is ~ 23-25 m^3/h.

(c) **Atmospheric Tank-** with the tank open to atmosphere, there is an element of evaporative losses that was not considered during the design phase that made assessing the sub-surface leak off rate more challenging. Following start-up in winter conditions, it was noted that the system is not truly closed – the tank itself is open to atmosphere and subject to evaporative losses given the 50ºC+ water temperature in the tank. The extent of the evaporative losses were unknown. Initial calculations were performed to attempt to quantify these evaporative losses, with these calculations suggesting that evaporation could account for a significant portion of the daily volume loss. The evaporation rate is challenging to calculate with confidence as some of the key parameters, i.e. the gas velocity above the water surface and the humidity ratio of air in the tank, are challenging to measure and small changes in these assumptions can have a large impact in the calculated result.

Therefore, a trial was undertaken to quantify the impact of evaporation on the overall leak off of the system, where hexa-covers were installed in the storage tank to reduce the exposed surface area of the tank and mitigate the evaporative losses. This was performed in February 2020, with the findings confirming that the majority of the system losses are actually driven by sub-surface leak off rather than evaporation.

(d) **Commercial Surface Facilities –** the project learnings will be transferred to a commercial project in that a pressurized vessel will be used for surge capacity instead of an atmospheric storage tank, and the well design will be such that the inlet and outlet wells are co-located on the same surface location so no pipeline will be required for commercial implementations.

6.3. Operations

(a) **Dispatchability –** a key learning from operating the system was the ability to operate an Eavor-Loop in a dispatchable manner. This was identified during start-up of the system, where the long residence time in the sub-surface loop resulted in a delay between making a process change and seeing the results at the outlet well. Using this methodology, an operating plan was developed to support dispatchable operation of an Eavor-Loop over a 24 hour period by charging the system (slowing down the circulating rate and heating up the subsurface fluid), and discharging the system (increasing the circulating rate to produce out this fluid). This will allow an Eavor-Loop to complement intermittent renewable energy sources such as solar and wind and expand the technology offering beyond a purely baseload solution.

(b) **Working fluid design –** Modification of the working fluid through addition of different chemistries has provided some learnings. These include both how to model the adjusted fluid properties and the impacts that these changes have to the overall process and the thermosiphon. Further, working fluid chemistry must be monitored frequently (at least monthly) to ensure it remains within design parameters.

(c) **Leak-Off Rate –** While the project is still performing better than the targeted leak-off success criteria, Eavor intends to continue testing various methodologies to lower the leak-off rate further.

7. Outcomes and Impacts

The ability to successfully execute this project, demonstrating that an Eavor-Loop can be drilled, sealed, and operated purely by a thermosiphon effect with thermodynamic results in agreement with the predicted output has ultimately unlocked a new source of geothermal energy that is now ready for commercial deployment.

The ability to design closed loop geothermal systems that have a predictable thermal output with no exploration risk is critical to scaling geothermal energy as a resource in the global energy stack. With Eavor-Loop technology, each unit of energy produced from a system and used either for direct heating or converted to electricity has potential to offset emitting sources generating an equivalent amount of energy.

Eavor is progressing numerous commercial projects around the world. None of these projects would advance without a clear demonstration and de-risking of the technology. Indeed, the completion of the project has accelerated project development and led to growing interest from partners and clients globally.

Execution of this demonstration project has supported Eavor's ability to access additional capital. In particular, since Alberta Innovates and Emissions Reduction Alberta approved the project Eavor has raised additional private funding, the vast majority of it coming from out of province (our two leading investors are Vickers Venture Partners, a venture capital fund based in Singapore, and a supermajor integrated energy company). In addition, the project is a necessary step to access public cleantech funding programs targeting commercial projects, such as the European Union Innovation Fund, European Investment Bank's InnovFin program, and the envelope of funding provided by the Canadian Government and administered by the Export Development Bank of Canada (EDC) to support first commercial implementations of Canadian cleantech technologies.

Overall, the project was successful in achieving the technical objectives set forth in the project plan, in addition to providing critical learnings that have been incorporated into commercial system design and execution plans. Further, testing of additional technology continues at the pilot – for example, dispatchable operations (time-shifting output to meet end-user demand). The pilot has also resulted in significant knowhow or trade secrets.

8. Benefits

8.1. Greenhouse Gas (GHG) Benefits

In regular operations Eavor-Loop™ generates no GHG emissions, no air pollution, has no water use, and has the smallest land footprint of any renewable electricity generation technology. If successfully commercialized, the technology will be increasingly adopted and replicated which has potential for large reductions in GHGs from electricity use worldwide.

The demonstration project itself was not grid-connected, so there are no direct GHG benefits from Eavor-Lite. The value from an environmental perspective is to enable widespread adoption of the technology in Canada and globally. In other words, all of the upside benefit is from indirect emissions reduction from large-scale replication. Indirect benefits are based on a forecast of Eavor-Loop™ installations in a "success-case" scenario, which assumes that commercialization of the technology is successful, and economies of scale drive down the cost of the standardized product. The key risk in achieving these indirect reductions is the rate of market uptake of Eavor-Loop™ technology.

The primary effect of Eavor-Loop™ is to produce zero-emissions, baseload/dispatchable electricity. Each commercial installation displaces electricity (and the corresponding GHG emissions) that would have been produced from GHG-emitting generation. Eavor's success case commercialization forecast assumes that Eavor-Loops will only be installed in a distributed scenario in Western Canada, primarily Alberta. Therefore, the baseline is assumed to be the average emissions intensity of the electricity grid in Alberta, which is heavily weighted towards natural gas.

Alberta's Technology Innovation Emissions Reduction (TIER) Regulation defines the methodology to calculate emissions reduction by using a "grid displacement factor". If an emissions-free generating source (such as Eavor-Loop™) provides electricity, it displaces electricity that would have been provided by carbon-emitting sources which make-up the grid. The regulations differentiate between grid-level displacement (530 kg CO2eq/ MWh), and distributed generation (570 kg CO2eq/MWh), to account for line losses in the transmission system (based on Alberta's Carbon Offset publication: link). In this evaluation, a displacement factor of 570 kg CO2eq/MWh has been used assuming that all Eavor-Loop™ installations are distributed in rural Alberta, selling to towns, communities, and industrial / commercial end-users.

Eavor-Loop™ does not produce any GHG emissions during regular operations, except for negligible emissions for mechanical maintenance, similar to wind/solar installations. However, there are emissions during construction stemming largely from electricity and diesel fuel consumption required for equipment, transport, drilling rigs, etc. Eavor has estimated the GHG intensity including construction emissions based on NRCan data showing 63 T CO2eq released during the drilling phase of conventional oil/gas wells (link). This has been combined with internal assumptions about Eavor-Loop™ drilling time (and confirmed with Eavor-Lite results), and drilling power required relative to oil/gas wells. Assuming all equipment is powered with diesel (rather than electricity), Eavor's construction emissions intensity is 1.9 T CO2eq/GWh.

To estimate the GHG impacts, Eavor built a forecast model of units deployed based on a "success-case", using the results from the demonstration project and assuming a capital efficiency learning curve. The growth rate of units deployed in Alberta is slow initially. As our product is a standardized, repetitive design, we plan to move down market (from higher margin international markets eventually into lower margin areas like Alberta) as we benefit from lower costs and a typical learning curve. As the capital efficiency improves, Alberta will become a target market and cumulative installations in Alberta begin to increase.

Figure 32 illustrates the forecast to 2040, with installed capacity increasing exponentially as capital efficiencies are realized. A key assumption to justify the exponential uptake of Eavor's technology is the dropping capital efficiency over time. This is a justified assumption as drilling time continues to drop (even faster than wind/solar costs) and great progress is already underway on testing and development of the second-generation system which significantly lowers costs. International installed capacity is projected to grow at a rate approximately quadruple that of Alberta installations, due to superior economics in other jurisdictions.

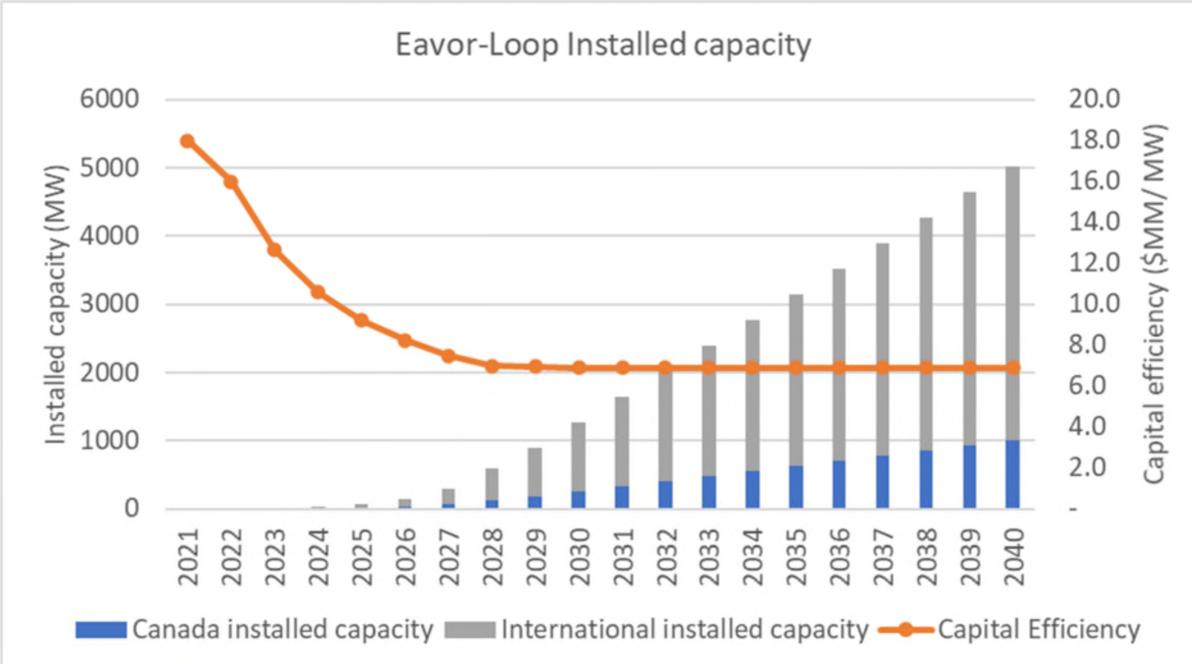


Figure 29 - Eavor-Loop Installed Capacity forecast

As capital efficiencies are realized and costs begin to plateau, growth is projected to shift from exponential to linear in nature. The intent is to continue to focus on improved efficiency through technology development and innovation which should allow for further cost reduction past 2030. Figure 31 illustrates the associated GHG reductions in Canada from the forecast (>95% are expected in Alberta).

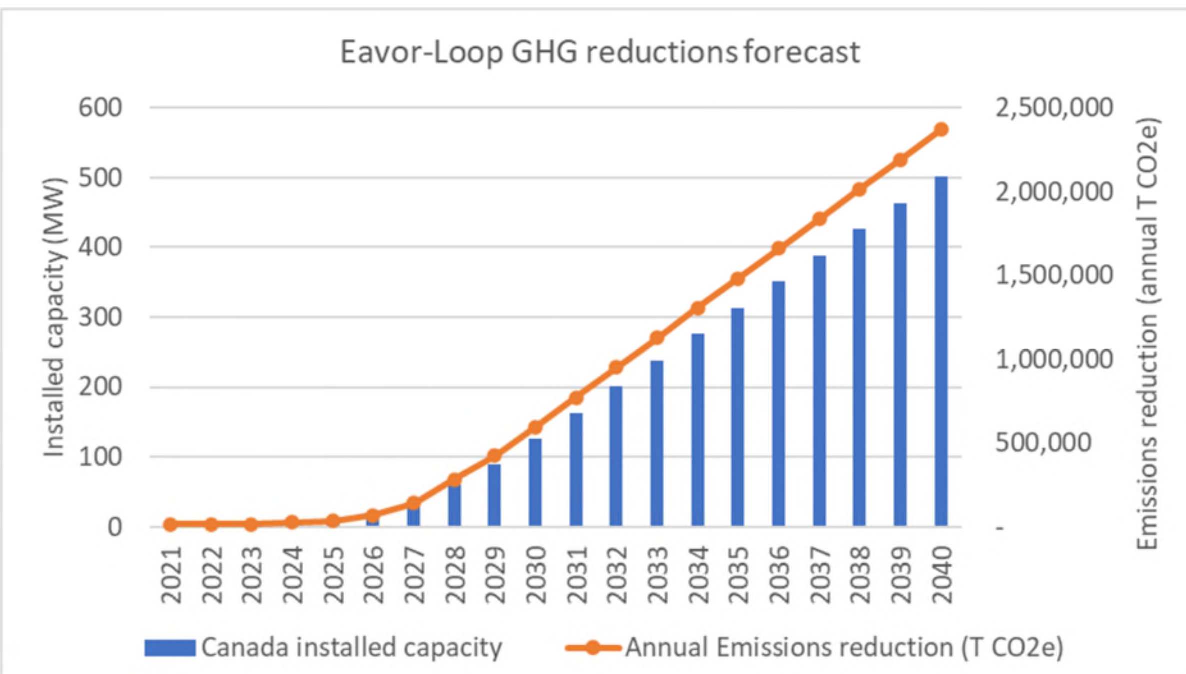


Figure 30 - GHG emissions reduction forecast

8.2. Alberta Economic Benefits

The Eavor-Lite project resulted in several significant economic benefits in Alberta:

- $12.5 MM direct investment in clean technology into the province
- Approximately 150 people employed during the planning and construction phase, most of them in an economically depressed region with high unemployment.
- Eavor hired and trained approximately 20 highly skilled professionals at the head office in Calgary
- The firm has been granted 2 patents in Canada, and has a further 12 applications pending. All 14 applications are filed in 25 jurisdictions globally, which could result in as much as 350 patents owned by Eavor Technologies Inc. Eavor is seen as the global leader in closed-loop geothermal and the first mover in this emerging industry.
- Since receiving Alberta Innovates and Emissions Reduction Alberta support, Eavor Technologies Inc. has raised an additional $48 MM, much of which will be invested in the province over the next several years.

Commercialization of Eavor-Loop™ technology has an enormous potential impact to Alberta. If Eavor is successful in driving down the cost learning curve the results would be a significant impact on greenhouse gas emissions in Alberta and in other jurisdictions; and repurposing of Alberta's industrial strengths to a new green export market worth several hundred billion dollars annually. Eavor is focusing on the immediate commercialization and deployment of this technology, initially targeting "low hanging fruit" internationally.

Note that Eavor expects to install more units outside of Alberta primarily due to better economics in other jurisdictions. However, a critical point is that many of the economic benefits still accrue to Alberta regardless of where the actual installation is. This is akin to the oil and gas industry where Alberta is a net exporter of technology, equipment, and engineering services.

Eavor-Loop™ represents an opportunity to re-purpose Alberta's existing world-class industrial base to a new green export industry. The economic benefits would be significant: 25,000 Full Time Equivalent positions by 2040, ~$2.6 Billion of additional investment, and $500 MM in annual revenue. These direct benefits would be multiplied several-fold through indirect hiring and tax revenue to the province. Figure 32 illustrates the potential. Labour and Highly Skilled Personnel requirements are based on Canadian Association of Oilwell Drilling Contractors (link) and Eavor estimates.

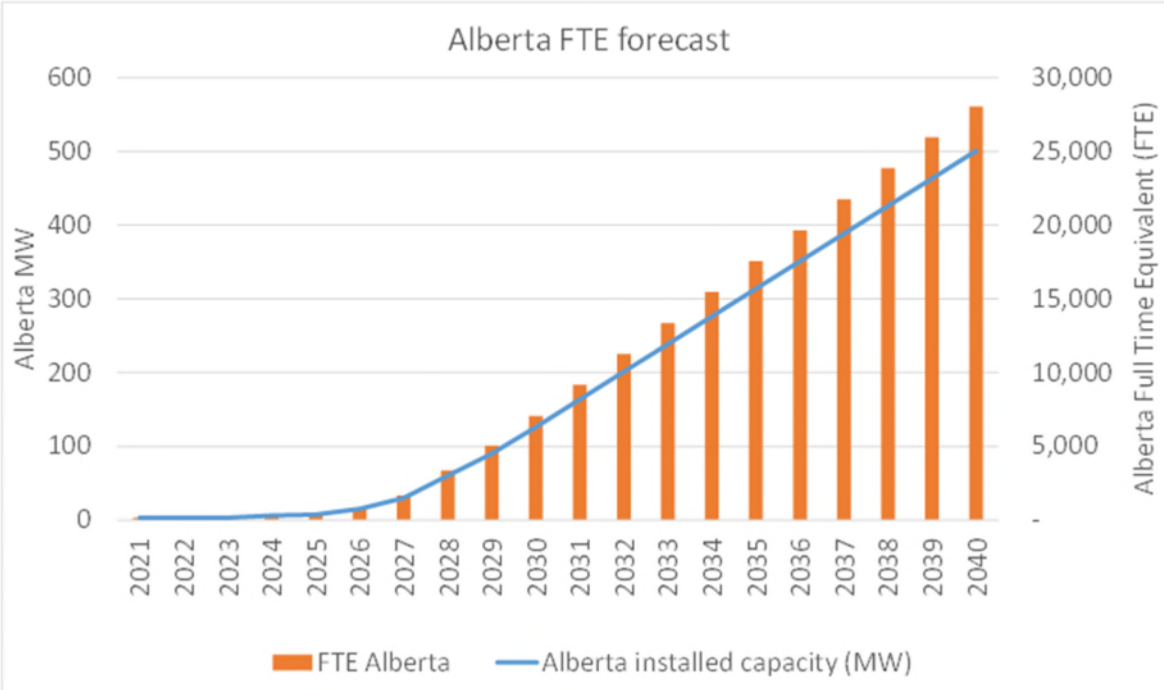


Figure 31 - Alberta jobs forecast upon successful commercialization

9. Recommendation and Next Steps

9.1. Commercialization Pathway

Eavor's business model is a hybrid between a technology company and an energy project developer. The technology will be dispersed through project development and Eavor's direct equity interest in the energy-generating assets. A technology license is also paid from the energy-generating asset to Eavor Technologies Inc. This model is flexible and enables structures like our Geretsried project (Eavor owns 90%, the local German partner retains 10%), to our Yukon business which is currently split with a group of First Nations, while Eavor retains operatorship and control on the technology. Each commercial project agreement that is secured will include Eavor's involvement in the front-end engineering and design of the project, the construction phase, and a long-term service agreement.

For the first several projects Eavor Technologies Inc. expects to directly own approximately 20% of the equity and also earn the technology license fee. As the technology becomes commercially proven Eavor will be financing projects through a separate entity with a lower cost of capital.

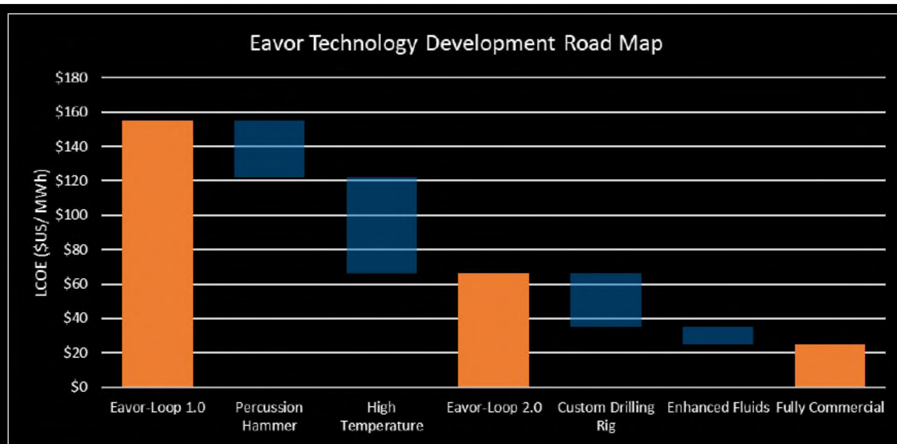
Eavor's commercialization strategy is to target premium markets ("low hanging fruit") while we are still at the top of the learning curve. As costs drop due to technology and economies of scale, Eavor-Loop™ will become economic in new segments and we will move "down-market", into broader and lower priced segments. In line with this strategy, Eavor has a project pipeline with more than 100 projects in various stages of development, primarily concentrated in northern Europe, US, and Japan. In 2021/2022, Eavor is targeting to reach a Final Investment Decision on 3-5 projects.

The main challenges to commercialization in Alberta are 1) it requires low costs to compete, given the low electricity prices and low geothermal gradient and 2) lack of geothermal and distributed energy regulations.

The first challenge is being addressed with improved technology, and by driving down costs and progressing through the learning curve in more lucrative markets. Figure 33 displays Eavor's technology roadmap and the impact it has on Levelized Cost of Energy. Eavor is well advanced in testing and development of "Eavor-Loop 2.0" technology – the 2nd generation system.

Eavor-Loop 1.0 Technologies proven at 2019 Eavor-Lite™ project:

1. Multilateral magnetic ranging intersection
2. Multilateral Rock-Pipe™ Completion method
3. Thermosiphon and Thermodynamic model



	Eavor-Loop 1.0	Eavor-Loop 2.0	Fully Commercial
Markets	• Direct Heat • High Feed-In-Tariff electricity markets • Remote (Islands, etc.)	+ these markets: • Dispatchable Electricity • Distributed Electricity	+ these markets: • Wholesale utility markets • Lower geothermal gradient regions

Figure 32 - Technology Roadmap

The geothermal industry is engaged in discussions with the Alberta government on the 2nd challenge. Recently Alberta's Energy Minister, Sonia Savage, initiated a press event to outline the Alberta governments plans to legislate geothermal regulations. Distributed energy regulations are not an absolute must, but will significantly help a geothermal industry in Alberta, as they enable much higher prices for local generation by avoiding transmission/distribution fees. Currently, distributed generation regulations only apply to physically "behind the fence" installations. Whereas an Eavor-Loop would typically provide power to a town or a few facilities – under current regulations if the power crosses a road, it is disqualified from micro-gen regulations.

Despite these challenges, Eavor intends to develop projects in Alberta once the first commercial projects elsewhere are operational. There is a significant potential for Eavor-Loop™ implementation in Alberta as the technology continues to be improved and de-risked through early-stage projects. There are several critical reasons to pursue Alberta as a target market:

- The drilling expertise that has enabled the Eavor-Loop™ to become a viable technology was generated to a large extent in Alberta through oil and gas development. There is a highly skilled resource pool available to deploy as soon as economically viable.
- Drilling equipment is available in Alberta (no need to import or upgrade equipment), and access to local partners is more readily available. For example, in the Eavor-Lite project we partnered with Calgary-based companies such as Precision Drilling, Shear Fluids, and Chinook Consulting Services.
- There is a clear political motivation to repurpose Alberta's industrial strengths to new industries.

10.Knowledge Dissemination

In addition to the published papers outlined in Section 7, the Eavor-Lite facility is open for scheduled tours for stakeholders to better understand the technology and observe the operations. An online virtual tour has also been developed that allows people ability to access the facility and learn about the technology without travelling to site, which was a big challenge in 2020 due to Covid-19. The online tour can be accessed here:

https://eavor.com/eavor-lite-virtual-tour

Eavor continues to build out the global project pipeline of commercial opportunities. The recent announcement by the Alberta Government that geothermal regulations will be introduced to legislation this fall is an important step forward in accelerating the ability to construct Eavor-Loops in Alberta. Significant efforts have been made in working with Alberta provincial and municipal governments, First Nations groups, and commercial business partners to progress opportunities for Eavor-Loop implementations in Alberta.

11.Conclusions

The Eavor-Lite Demonstration Project has been successful in demonstrating the technology to construct and operate an Eavor-Loop™ and produce commercially viable heat or electricity. Completion of this project has provided credibility to Eavor Technologies to pursue commercial scale developments of the technology. The outcome has been to unlock opportunities to deploy this technology worldwide, allowing for progression down the cost curve and increasingly improved economics of future projects. Commercial projects in Alberta are already under development with major partners in the province and will be commercialized as the technology progresses.

Utility scale amounts of heat and power generated from scalable Eavor-Loop projects will displace higher emissions sources of energy and contribute to meeting emissions reductions goals in all jurisdictions in which they are deployed. Alberta will continue to benefit from all Eavor-Loop projects constructed in Alberta or around the world through the employment of Alberta’s highly skilled personnel in the Calgary head office and ecosystem. Additionally, Eavor’s business model will provide export revenues and income to Alberta from around the world.