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Sustainable Geothermal Reservoir System Multilateral Flow Patterns for Optimal Heat Energy Production in Saskatchewan

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ABSTRACT

Geothermal Energy is widely recognized as a renewable, sustainable, and environmentally friendly source of energy due to its low carbon footprint. However, the amount of heat energy extractable from a geothermal system strongly depends on the reservoir flow dynamics, which requires critical reservoir characterization for long-term productivity, energy output maximization, and heat extraction efficiency. This study presents a comparative study of heat energy recovery efficiency for production-injection flow patterns generated by vertical, horizontal, and multilateral wells in a geothermal reservoir. Each well configuration exhibits distinct characteristics that affect thermal recovery as well as the overall heat energy efficiency. Vertical well configurations can reach high reservoir temperatures at depths with expensive drilling, and have a lower cooler injected fluid contact area that reduces heat extraction efficiency. Whereas horizontal wells enhance thermal recovery and heat transfer rate due to their broader area and lateral spread. However, drilling many horizontal wells could be quite costly. Nowadays, the application of advanced multilateral technology that blends vertical and horizontal flow patterns by maximizing heat extraction and enhancing energy efficiency through the access of different geothermal reservoir zones as multilaterals diverge from a single wellbore provides future geothermal energy industry solutions at the lowest drilling cost. This article analyzes temperature distribution along the geothermal reservoir system life cycle, compares energy efficiencies, and performs economic analysis for the three types of flow patterns. The case study is based on the data collected from the 1979 On-Campus Geothermal Project from the University of Regina. The research findings are expected to support sustainable and optimal geothermal well heat production performance in western Canada.

1 INTRODUCTION

Geothermal energy offers enormous potential to achieve the global demand goal of lowering carbon emissions from non-renewable energy sources by switching to a more sustainable energy source. Geothermal energy can supply all-weather renewable energy with a low carbon footprint, unlike fossil fuels. Therefore, the development of geothermal renewable energy can benefit both large-scale industrial applications and home uses, such as low-temperature geothermal direct use applications for heating, cooking, therapeutic bathing, and more (GeoVision, 2025). Canada's investment in sustainable energy has not resulted in any operational geothermal facilities, primarily due to competition from more affordable energy sources and regulatory issues at the territorial level (Geothermal Canada, 2024). Geothermal facilities, despite their high initial costs, have the potential to produce sustainable revenue and provide clean electricity for numerous households (DEEP, 2021). Multilateral drilling technology presents potential for energy recovery at reduced costs; however, the challenges of substantial management expenses, a lack of familiarity with the technology, and a deficit of adequately trained skilled workers contribute to its limited adoption (Shor et al., 2023). The limited reach of these multilateral wells drilling presents challenges in comprehensively assessing their long-term sustainability, intricate flow dynamics, and thermal coupling mechanisms. This study explores sustainable geothermal flow patterns that use advanced multilateral technological solutions to increase geothermal reservoir reach and maximize sustainable energy production recovery in Saskatchewan and Canada. The SLB (2023) technical study of the DEEP Geothermal Project affirms Saskatchewan's geothermal resources' long-term energy production potential. The DEEP Geothermal Project will build multilateral horizontal wells in binary configurations to generate baseload power from 4 MW to 20 MW for Phases I and II, with a 180 MW project capacity. The 4 MW and 20 MW base load power can theoretically supply renewable energy to 4800 and 25000 homes, respectively, transforming the lives of 74% of Saskatchewan residents who rely heavily on coal (DEEP, 2021).

2 EXISTING LITERATURE ON ADVANCED MULTILATERAL DRILLING APPLICATIONS TECHNOLOGY IN GEOTHERMAL RESERVOIR SYSTEMS

Recent studies have projected the application of multilateral drilling techniques to enhance geothermal system efficiency through improved contact and fluid flow within the geothermal reservoir. Ren et al. (2020) conducted a 3D THM analysis in low-permeability multilateral wells, indicating higher energy outputs ranging from 5.5 MW to 7.25 MW. Shi et al. (2021) assessed that ML wells drilled with longer lateral length and proper well spacing improve heat extraction in EGS. Wang et al. (2022) demonstrated that multilateral wells have eight times the energy extraction efficiency of typical systems due to reduced input impedance. Wang et al. (2024) further supported that wells with several branches achieve 60% higher heat recovery than vertical wells. Zhang et al. (2024) further demonstrated that multilateral layouts can generate approximately ten times the thermal power of vertical wells, enhancing economic efficiency. However, Esmaeilpour et al. (2023) investigated closed-loop multilateral systems and contrasted that multilateral drilling completion may not always outperform traditional systems; more lateral wells in a horizontal direction need to be incorporated into the geothermal system design. Another study examined a single well geothermal system with numerous multilateral drills, demonstrating that, provided the target reservoir has adequate permeability, the system's performance may be sustained for a long extraction period (Erol et al., 2021). The existence of such literature, together with Huang (2018-2019) and SLB (2023) review on deep geothermal, emphasizes the benefits of optimized multilateral well configurations for enhancing the performance of geothermal systems, and this has been the motivation for the current unique geothermal project in Saskatchewan by companies, such as DEEP earth energy production corporation, to implement its first-ever and unique multilateral horizontal well drilling with an overall 180 MW sustainable power supply projections (SLB, 2023).

3 GEOLOGY OF TARGET GEOTHERMAL AQUIFERS IN SASKATCHEWAN

Comprehensive well testing and deep drilling undertaken between 2018 and 2019 showed that the basal sands of the Williston Basin's Deadwood formations have the potential to generate renewable geothermal electricity for the province. This deep drilling well completion serves as a benchmark to improve the current DEEP geothermal project reservoir model and estimate an appropriate horizontal well length and spacing (Huang et al., 2024). The DEEP geothermal project in the Williston Basin's Deadwood formation aims to create a multilateral horizontal well field that can potentially generate hot water at 120 °C to 125°C. This temperature is not as high as in volcanic geothermal reservoirs. However, the sedimentary basin's permeability, thickness, and storage capacity allow for high fluid production, making it suitable for a binary geothermal plant (Huang et al., 2024). The geological target Regina's Geothermal reservoir is categorized into three subdivisions, i.e., the Basal Clastic Unit (200m thick), Carbonate-Evaporite Unit (1000m thick), and Upper Clastic Unit (1000m thick) (Zhao et al., 2023). Table 1 shows the parameters of five aquifers of the Winnipeg-Deadwood formation that were used in this study.

Table 1. Parameters of the five aquifers of the Winnipeg-Deadwood formation (Zhao et al., 2023).

Formation	Aquifer	Lithology	Net effective thickness (m)	Ave. porosity (fraction)	Ave. permeability (md)
Winnipeg	Winnipeg	Sandstone, Quartzose sandstone	31	0.152	70
Deadwood	Upper Deadwood	Sandstone, cemented, Inter-beds	14	0.112	104
	Middle Deadwood	Sandstone, Glauconitic, Shale Inter-beds	24	0.121	104
	Lower Deadwood	Sandstone, Glauconitic, Kaolinitic, Shale Interbeds	23	0.127	104

4 RESEARCH METHODOLOGY

The numerical simulation of the target deep geothermal multilateral horizontal ribcage configuration and the Regina's single multilateral wellbore reservoirs was conducted using CMG modelling workflows, Builder using the STARS simulator model that incorporates advanced and complex industrial thermal processes. For comparison purposes, our previous study compared the simulation results from COMSOL Multiphysics V6.1, 2023 software with those from CMG software, and both simulation results predicted the same trends in production temperature and heat extraction rates. However, COMSOL results exhibit early thermal breakthrough, underestimating geothermal energy production, making CMG our choice for this study. GeoVision (2025) reported the conceptualized cut-way of the earth's temperature at the centre of the earth's core (about 6500 km) and 4000 miles deep to be the same as the surface of the sun (nearly 6000 °C), with temperatures increasing with depth. Therefore, this numerical simulation study considers the geothermal production temperature as a function of geothermal gradient and depth, as shown in equation 1 below.

$$T_2 = T_s + G.\Delta Z \quad (1)$$

Where;

- T_2 = Final production temperature (°C)
- Ts = Surface temperature of the target region (°C)
- G = Geothermal gradient (°C/m)
- ΔZ = Change in depth (m)

5 STUDY CONTENT AND DISCUSSION

The study content consists of four parts: 5.1-the criteria used for choosing the reservoir size, 5.2-model assumptions and aquifer simulation parameters, 5.3-Evaluate the performance of the proposed multilateral horizontal well configuration for deep geothermal heat energy production, and 5.4-Evaluate future expansion of the current Regina's single geothermal well incorporating multilateral drilling technology.

5.1 Criterion of the chosen reservoir size

This reservoir size was determined after performing numerical simulations for four horizontal multilateral production and three injection wells in an expansive reservoir model, roughly double the size of the specified area, measuring 12.5 miles by 12.5 miles under similar reservoir conditions. The larger model (12.5 by 12.5 miles) took longer to simulate than the smaller model (6.4 by 6.4 miles), but showed a slight increase in production efficiency (% (ΔT) in the range of 0.08 to 0.1, contingent on the production rate (Table 3). This little variation makes the selected model reliable for anticipating outcomes in an infinite geothermal reservoir aquifer. Table 2 illustrates this outcome, where λ represents the separation distance between the producer and injector, T1 denotes the minimum usable temperature at a specified time (t), and the temperature differential between the final production temperature, T2, and T_1 is ΔT.

Table 2. Well performance for four binary producers and three binary injectors (4 Pw & 3 Iw) in an open-hole multilateral horizontal well configuration producing at various constant production rates, under the same reservoir conditions but different reservoir size.

t = 40 Years	Surface water		$Pw_{1,4}$				$Pw_{2,3}$			
Reservoir Size	Production Rate, q	λ	T_1	T_2	ΔT	% ΔT	T_1	T_2	ΔT	% ΔT
miles	m^3/D	m					°C	°C	°C	%
6.4 X 6.4	6000	500	60.15	60.63	0.48	0.79	59.58	60.63	1.05	1.73
	7200	500	59.74	60.63	0.89	1.46	58.95	60.63	1.68	2.77
	8400	500	59.28	60.63	1.35	2.23	58.25	60.63	2.38	3.93
12.5 X 12.5	6000	500	60.20	60.63	0.43	0.71	59.62	60.63	1.01	1.67

	7200	500	59.79	60.63	0.84	1.39	58.99	60.63	1.64	2.70
	8400	500	59.34	60.63	1.29	2.21	58.31	60.63	2.32	3.83

5.2 Model Assumptions and Aquifer Parameters

This geothermal reservoir model is based on the assumption of a constant temperature boundary condition. While this may lead to an overestimation of production, it is important to note that the net effective reservoir thickness is relatively modest. Consequently, the production outcomes are expected to align closely with the constant boundary condition scenario. Additionally, the model adheres to the principle of mass conservation, stipulating that the amount of hydrothermal working fluid injected equals the amount produced. Moreover, the model incorporates conduction and convection as the primary mechanisms for heat transfer, with radiation effects not being considered. The aquifer parameters in Table 3 were used in this study to simulate both DEEP and Regina's geothermal aquifers.

Table 3. Simulation Aquifer parameters used in geothermal multilateral horizontal configuration and future expansion of the current Regina's single well multilateral geothermal reservoir.

Parameter	Value	Unit
Reference Pressure, P_r	30000	kPa
Formation Compressibility	4.57×10^{-7}	1/kPa
Reference Depth, D_{ref}	2000	m
Max. BHP	32000	kPa
Net Pay	80	m
Surface Temperature, T_s	10	°C
Injected Fluid (H_2O) Temperature	10	°C
Thermal Gradient, G	0.02476	°C/m
Thermal Conductivity of rock phase, k_r	2.16×10^5	J/ (m. day.°C)
Volumetric Heat Capacity	2.347×10^6	J/(m^3.°C)
Over-burden/Under-burden	2.347×10^6	J/(m.day.°C)
Viscosity, μ	0.65	cp
Volumetric Production/Injection rate, q	6000-8400	m^3/D
Thermal conductivity of water phase, k_w	4.84×10^4	J/ (m.day.°C)
Liquid compressibility	7.0×10^{-7}	1/kPa

5.3 Performance of open-hole multilateral horizontal ribcage well design

Figure 1 schematic represents the binary arrangement using open-hole multilateral horizontal wells for geothermal heat energy production, constructed with laterals extending 3000m, resulting in a total wellbore length of 6000m. The lateral pair separation distance (λ) between horizontal production and injection wells is (λ = 500m). In this study, 12 horizontal production wells and 10 horizontal injection wells were drilled to a vertical depth of 2000m into the Deadwood formation.

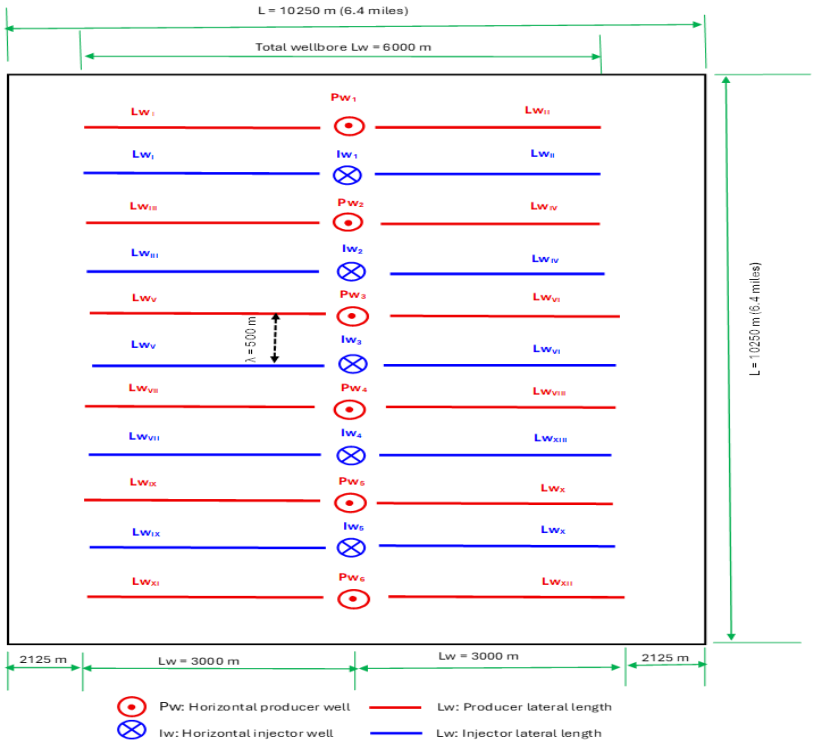


Figure 1. Schematic Ribcage for multilateral horizontal well design

The fundamental design case for this study comprises three binary horizontal production wells and two binary horizontal injection wells (3 Pw and 2 Iw). Additional horizontal multilateral production and injection wells were incorporated into the model in phases, specifically 4 Pw and 3 Iw, and subsequently 6 Pw and 5 Iw. The total wellbore lateral length for each horizontal production and injection well is (Lw =6000 m), and the well pair separation distance between horizontal production and injection wells is (λ = 500 m) apart. These horizontal multilateral production and injection wells were drilled into the Winnipeg-middle Deadwood formation, which has an average permeability of k = 104 md, as indicated in Table 1. The simulation results depicted in Figure 2 illustrate the general performance of the outermost multilateral horizontal production wells for each well configuration, operating at constant surface water production rates spanning from 6000 m^3/day to 8400 m^3/day. Under constant-rate production conditions, the fundamental engineering principle stipulates that production as a function of time is normally high from the early years and progressively decreases over time, leading to well depletion and abandonment as a consequence of diminished production efficiency. Under constant production rates depicted in Figures 2(a), 2(b), and 2(c), it is evident that the horizontal well configuration with 6 Pw and 5 Iw achieves the optimal production temperature, whereas the configuration with 3 Pw and 2 Iw exhibits the lowest production temperature. This phenomenon is attributed to the phased incremental addition of production and injection wells, which enhances reservoir interactions with a greater reservoir volume, thereby ensuring adequate heat transfer into the geothermal reservoir system, leading to improved production efficiency. Furthermore, with an increased number of production and injection wells featuring extensive lateral reach, the reservoir fluid can access high-pressure zones, thereby aiding in the maintenance and stabilization of production temperatures that can consequently help in extending the thermal breakthrough period of the geothermal system. Due to inadequate geothermal heat transfer into the reservoir system, the horizontal well configuration with 3 Pw and 2 Iw exhibits an insufficient heat extraction rate, accounting for the greater production temperature drop at the end of the production period. However, the overall production performance of the three horizontal well configurations remains notably sustainable, with the least effective well configuration experiencing a production temperature drop of ΔT = 2.92°C for q = 8400 m^3/day after 40 years of operation. These simulated results illustrate the potential for horizontal well configurations, with optimal well spacing, to deliver a sustainable energy supply beyond the typical geothermal energy lifespan. At a grouped constant production rate of q = 8400 m^3/day, each horizontal production well for the well configuration with 4 Pw and 3 Iw achieved a base

load power of 4.37 x 10^{11} J/day (5.06 MW), equivalent to (20.2 MW) for four production wells. This output power is capable of offering huge economic benefits to large-scale renewable energy projects that drive for a clean energy supply. Therefore, based on these simulation results, a strategically well-designed horizontal multilateral well configuration with an increasing number of production and injection wells with extended lateral reach plays an essential role in optimizing the geothermal reservoir system by maximizing heat transfer efficiency, stabilizing production temperatures, and extending the operational lifespan of the geothermal system.

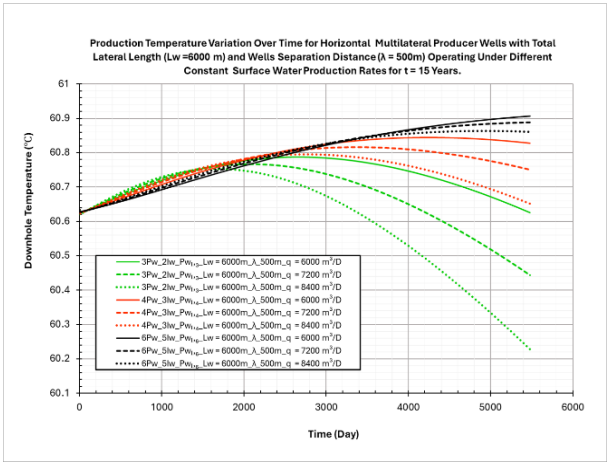


Fig.2 (a) Production Temp, λ = 500 m, t = 15 years.

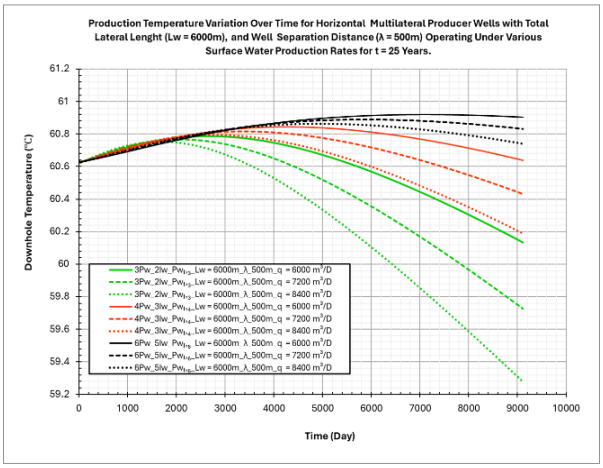


Fig.2 (b) Production Temp, λ = 500 m, t = 25 years.

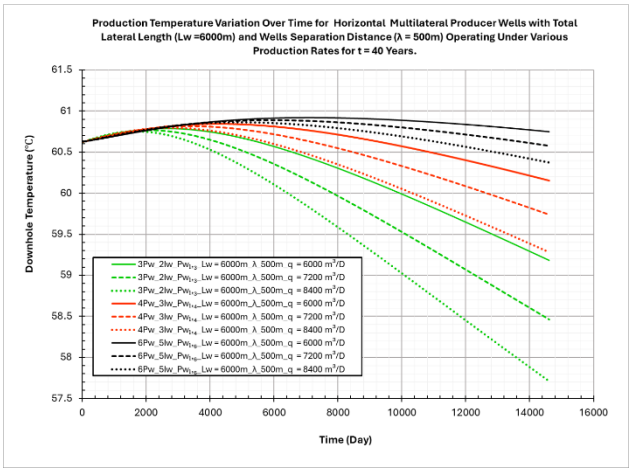


Fig.2 (c) Production Temp, λ = 500 m, t = 40 years.

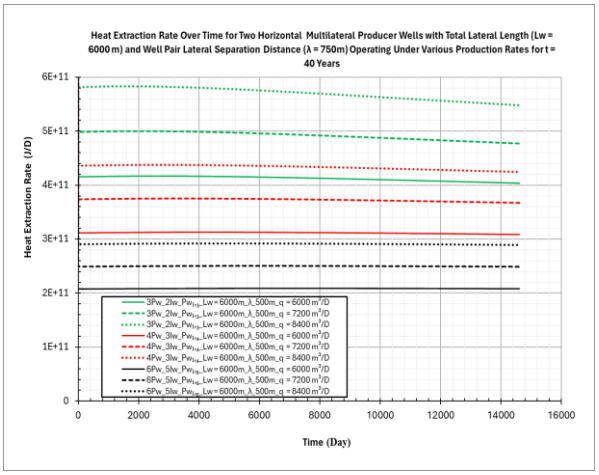


Fig.2 (d) Heat. E. Rate, λ = 500 m, t = 40 years.

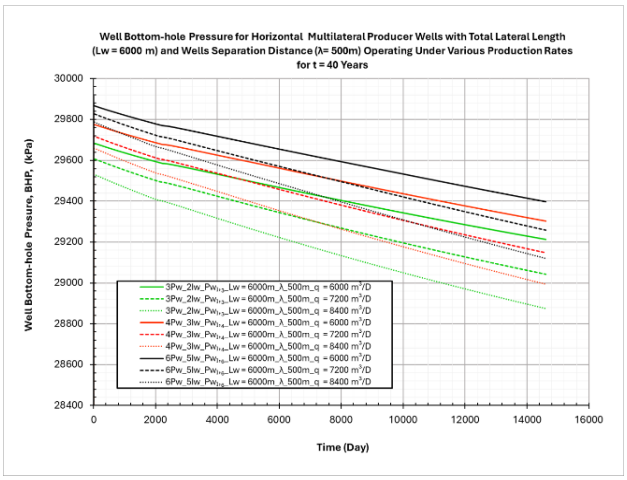


Fig.2 (e) BHP, λ = 500 m, t = 40 years.

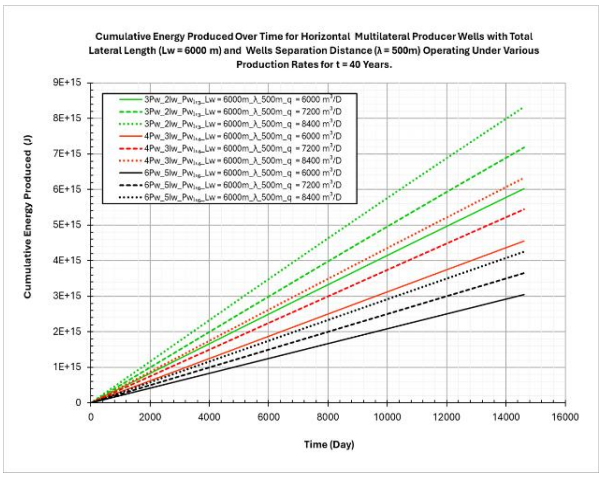


Fig.2 (f) Cumulative Energy, λ = 500 m, t = 40 years.

Figure 2. Production temperature distribution, heat extraction rate, well BHP, and cumulative energy produced for outermost horizontal multilateral producer wells with well pair separation distance, λ = 500m and total lateral length, Lw = 6000m operating under different constant surface water production rates.

Based on the simulation results in Figure 2, the production efficiency for horizontal multilateral well design increases with the increasing number of production and injection wells. Therefore, this implies that the performance of horizontally drilled production and injection wells, especially those with fewer production and injection wells, would require further design stage optimization to maintain production temperature efficiency and production flow rates. The simulation results depicted in Figure 3 evaluate the implications of greater separation distance between horizontal well pairs (λ) and extended total wellbore lateral length (Lw) on production temperature and heat extraction rates. The well pair for separation distance was increased from λ = 500 m to λ = 750 m, while the total wellbore lateral well length for each production and injection well was extended from Lw = 6000 m to Lw = 7000 m and Lw = 8000 m. Considering the horizontal well configurations with a reduced number of production and injection wells (2 Pw & 1 Iw, 3 Pw & 2 Iw, and 4 Pw & 3 Iw), Figure 3 production results demonstrate that the production temperature for the horizontal production well with greater well spacing (λ = 750 m) remained consistently stable over time compared to the well with a shorter lateral spacing (λ = 500 m) as indicated in Figure 3 (e). This is attributed to increased production and injection well spacing, which significantly optimizes production flow rates which enhancing fluid interaction within the geothermal system and reducing production temperature drops, resulting in an extended thermal breakthrough, improving the overall production efficiency of the geothermal reservoir system. Furthermore, at a constant production rate, increasing the horizontal wellbore lateral length subsequently improves production efficiency. However, this finding also suggests that horizontal lateral drilling could be feasible and cost-effective up to approximately Lw = 7000 m, as extending to Lw = 8000 m does not significantly impact energy production owing to the negligible production temperature increase beyond this length, as demonstrated in Figure 3 (f). Therefore, the horizontal well configuration characterized by a greater well pair separation distance and an extended horizontally drilled total wellbore lateral length has the potential of providing a sustainable long-term energy supply.

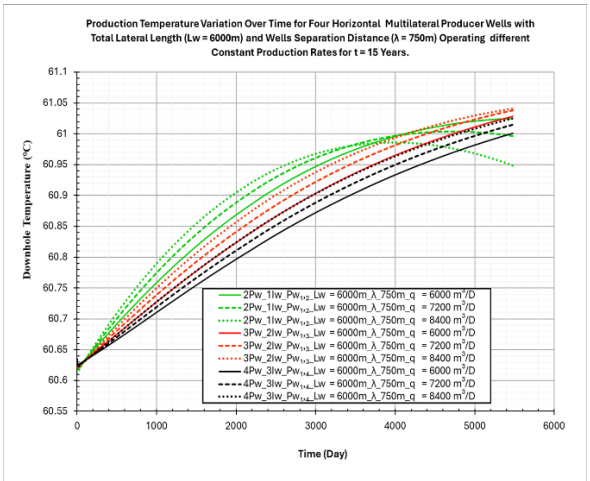


Fig.3 (a) Production Temp, λ = 750 m, t = 15 years.

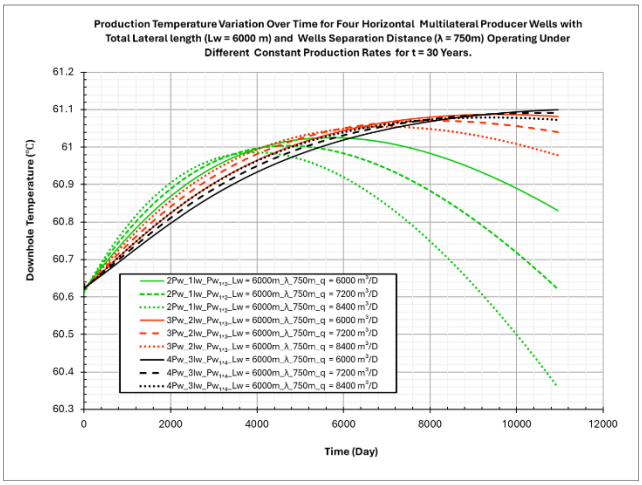


Fig.3 (b) Production Temp, λ = 750 m, t = 30 years.

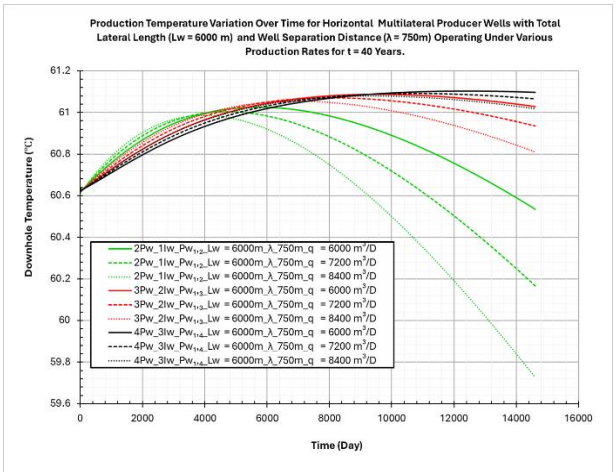


Fig.3 (c) Production Temp, λ = 750 m, t = 40 years.

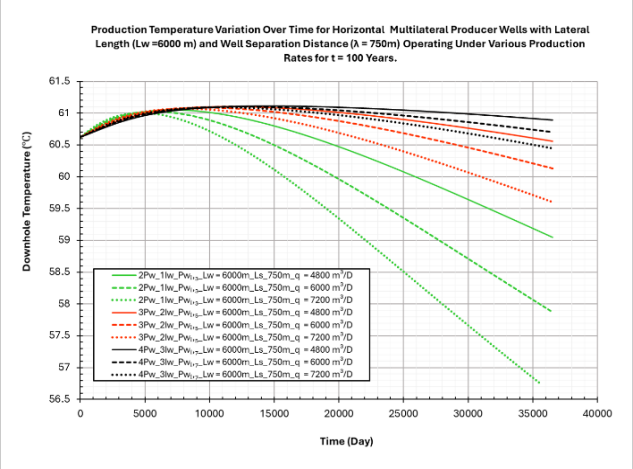


Fig.3 (d) Production Temp, λ = 750 m, t = 100 years.

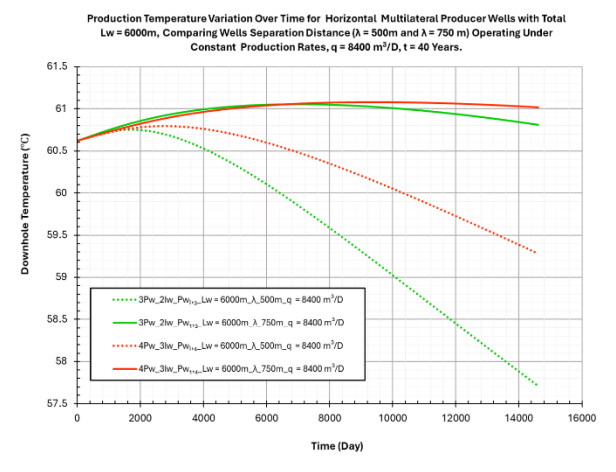


Fig.3 (e) Comparing λ = 500 m, λ = 750m, q = 8400 m^3/D

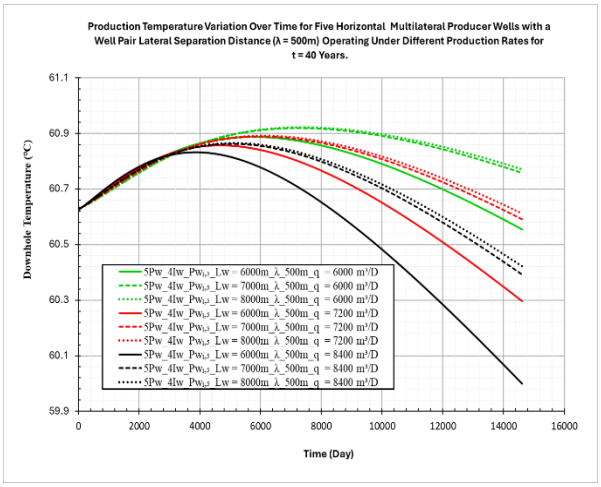
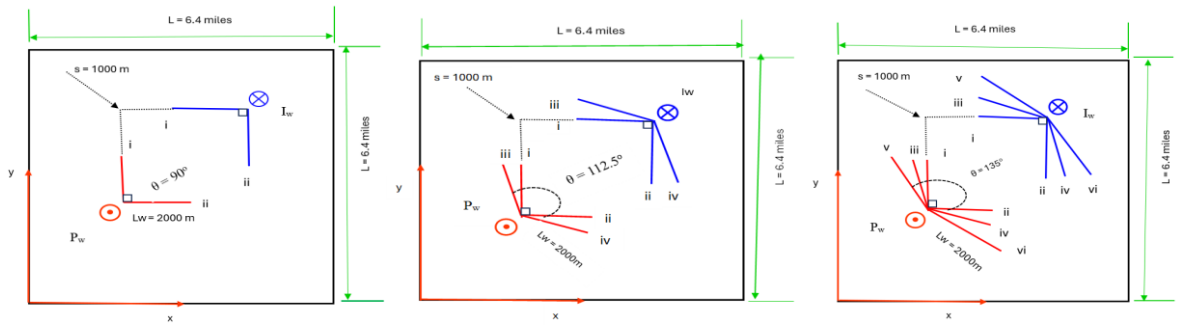


Fig.3 (f) Optimized Lw (6000m - 8000m) for 5 Pw & 4 Iw

Figure 3. Optimization of lateral well pair separation distance (λ) and well length (Lw) using multilateral horizontal producers and injectors (5 Pw & 4 Iw) to enhance production flow rates and improve production efficiency.

5.4 Future integration of the current Regina's single geothermal well by incorporating multilateral drilling technology.



(a) 2 L_o at 90°

(b) Additional 2L_o at 112.5°

(c) Additional 2 L_o at 135°

Figure 4. Schematic for a single wellbore with multilateral drilling laterals positioned at diverging angles.

To evaluate the potential benefits of multilateral drilling technology for sustainable energy development, the current 1979 On-Campus Geothermal Regina geothermal project could be improved by integrating multilateral drills that extend from the same production and injection single wellbore. Figure 4 presents the design of a single

wellbore, incorporating the prior reservoir size model and taking into account horizontal, vertical, and deviated lateral orientations. The first two lateral $2L_o$ (where L_o indicates the number of laterals) have a lateral length (Lw = 2000 m) and are oriented at 90° for both the production and injection wells. Two additional $2L_o$ lateral drills oriented at 112.5° were incorporated into the existing model, followed by two more $2L_o$ positioned at 135°. This adjustment resulted in a total of $6L_o$ laterals for both production and injection within a single wellbore. The distance separating the perforated production wells from the injection wells measures 1000 m. This is essential, especially for the first two laterals positioned at 90 ° to avoid early thermal breakthrough. Figure 5 presents a summary of the production outcomes for single-wellbore multilateral configurations (a, b & c) in conjunction with the performance of a single well featuring only a vertical lateral drill. Figure 5(a) illustrates the temperature distribution for a single-wellbore production well as it incorporates increasing multilateral configurations (a, b, & c), in contrast to a single wellbore featuring a single main vertical lateral drill. The temperature distribution for a single wellbore with multiple multilateral drills shows a higher production temperature than that of a single wellbore featuring one main vertical lateral drill of equivalent lateral length, which exhibits a more rapid decline in production. This is attributed to the fact that a single wellbore with multilateral drills at diverging angles can access a larger reservoir volume, which enhances geothermal fluid circulation, leading to improved heat extraction rates, ultimately leading to enhanced sweep efficiency within the geothermal system. Additionally, gaining access to a larger reservoir contact facilitates entry into higher-pressure zones, which contributes to the maintenance of production temperatures and further delays the thermal breakthrough of the geothermal system. However, the supply of heat energy from a single wellbore with one vertical lateral drill is inadequate, resulting in a more significant production temperature drop compared to a single wellbore with multiple multilateral drills. This limitation renders it ineffective for sustaining and providing an energy supply over an extended period. Following four decades of consistent production at a rate of q = 8400 m^3/D and Lw = 2000 m, a single well featuring a vertical lateral drill, $1L_o$, achieves a heat extraction rate of 1.62 x 10^{12} J/D (18.75 MW). In contrast, a single wellbore equipped with $6L_o$ multilaterals yields a production of 1.76 x 10^{12} J/D (20.37 MW). Additional optimization for a single well utilizing multilateral drills with an extended lateral length of 3000 m indicates improved well performance as compared to a lateral length of Lw = 2000m. The improved performance can be linked to the enhanced sweep efficiency, which results in a more effective heat extraction rate and prolongs the risk of thermal breakthrough, ultimately contributing to increased output energy recovery. Consequently, the implementation of multilaterals drilled from a single wellbore at diverging angles significantly enhances the efficiency of the geothermal system.

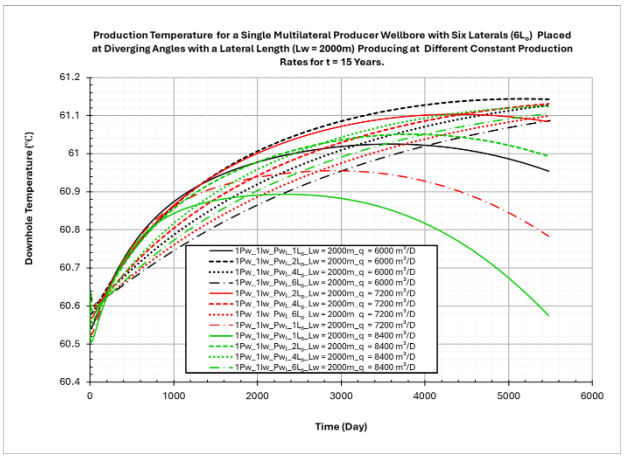


Fig.5 (a) Production Temp, Lw = 2000 m, t = 15 years.

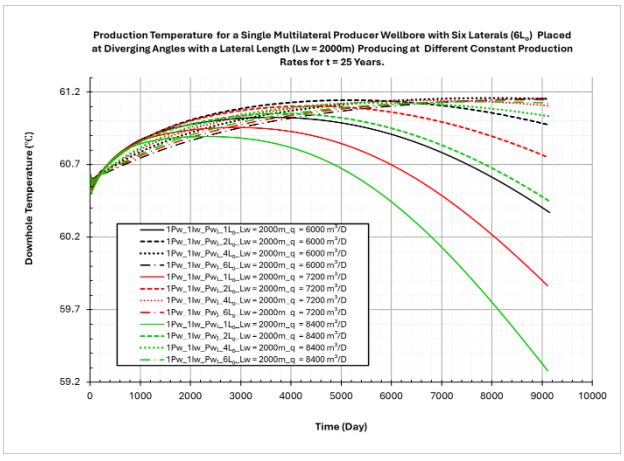


Fig.5 (b) Production Temp, Lw = 2000 m, t = 25 years.

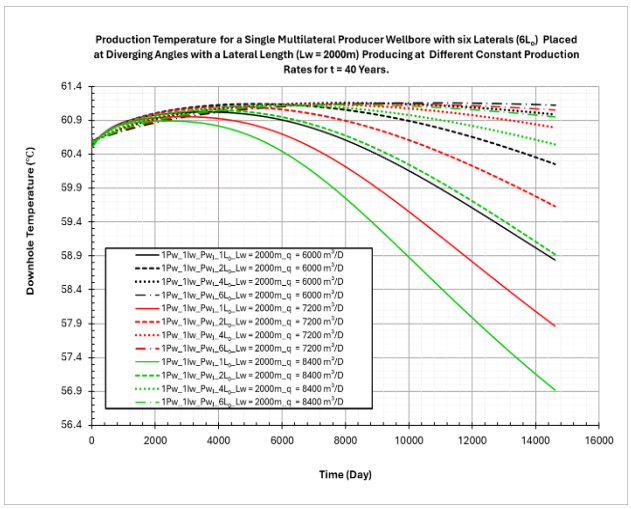


Fig.5 (c) Production Temp, Lw = 2000 m, t = 40 years.

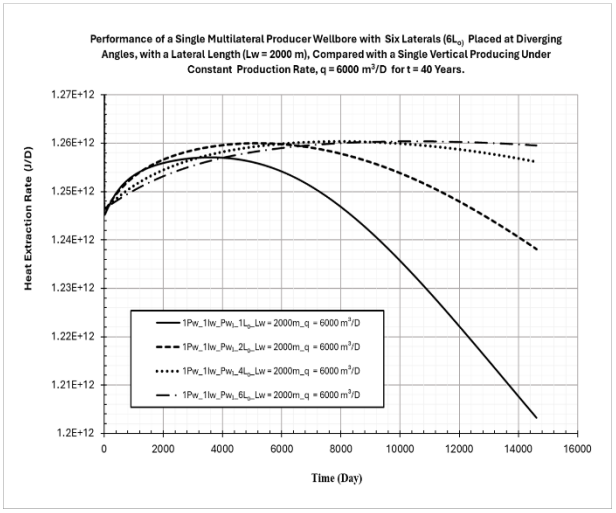


Fig.5 (d) Rate, Lw =2000 m, q = 6000 m^3/D, 40 years.

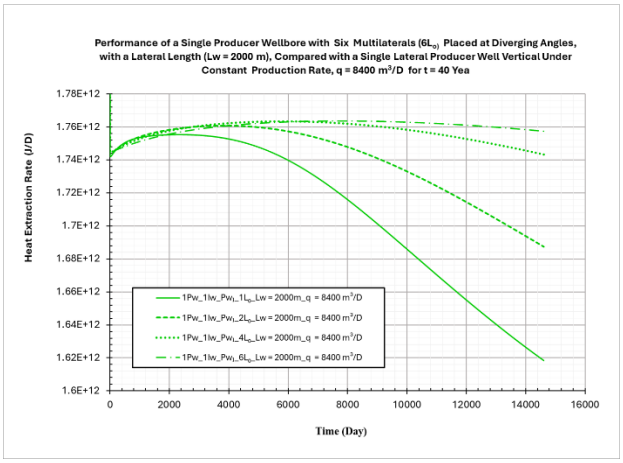


Fig.5 (e) Rate, Lw = 2000 m, q = 8400 m^3/D, 40 years.

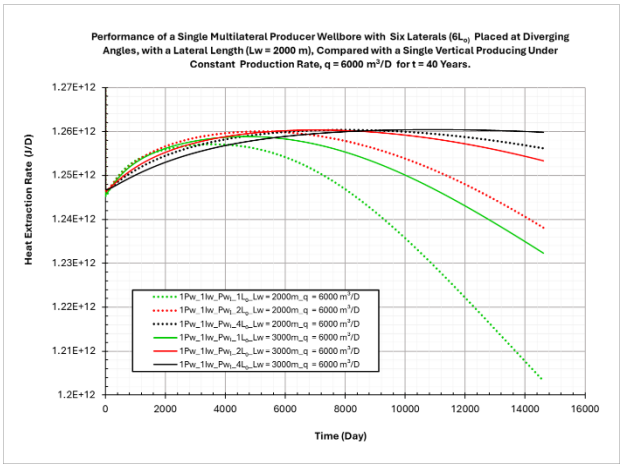


Fig.5 (f) Lw = 2000 m, Lw =3000 m, q = 6000 m^3/D.

6 CONCLUSION

1. The research findings obtained from this study indicate a considerable opportunity for a technological advancement in deep geothermal multilateral drilling. The findings indicate a sustainable and efficient approach to geothermal energy heat production and could provide a foundational reference for informed decision-making in engineering well design and optimization. The findings from the current SLB evaluation regarding the proposed DEEP Geothermal Project development in Saskatchewan, Western Canada, are supported by the simulation results, although they are constrained by the available field data. Accurate predictions regarding well performance are contingent upon the availability of actual field data. The existence of the actual field data allows for increased and more accurate data representation.

2. To optimize the performance of fewer horizontal production and injection wells, it is essential to maintain the production temperature, ensure adequate fluid circulation and heat exchange, and enhance sweep efficiency. It is fundamental to appropriately consider the design stage well optimization to mitigate the risk of early thermal breakthrough. This could be achieved by extending the well lateral length (Lw) and increasing the separation distance between well pairs for horizontal wells, enhancing the flow rates and overall efficiency. The simulation results indicate that extending horizontal multilateral wells to an average total well length of 7000 m proves to be cost-effective, given that there is no notable production temperature variation at 8000 m. At a separation distance of λ = 500 m, the production temperature remains stable, exhibiting only a slight decrease in temperature difference after 40 years. In contrast, at λ = 750 m, the geothermal reservoir demonstrates the capacity to produce at a rate exceeding the average lifespan of geothermal resources, owing to its enhanced ability to extract heat from the reservoir over an extended duration.

3. When evaluating the performance of a single lateral well, the integration of horizontal multilaterals in phases, along with the use of horizontal, vertical, and deviated lateral orientation drilling technology for a single

multilateral wellbore, significantly improves sweep efficiency, heat extraction, and reservoir pressure maintenance. This approach also mitigates the risk of early thermal breakthrough, thereby optimizing geothermal energy solutions by maximizing production while minimizing costs.

4. Given the minimal variation in production temperature difference, the chosen model is reliable for forecasting the outcomes of an infinite geothermal reservoir aquifer.

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