

Achieving Step-Change Operational Performance Through Innovative Application of Coiled Tubing and Contractor-Client Partnership

Karl Spinks¹, Ted Montague², Dane Coppel¹ and Mike Dunstall²

¹ Western Energy Services, Taupo, New Zealand

² Contact Energy Ltd., Taupo, New Zealand

karl@westernenergy.co.nz

Keywords: cost-effective, innovation, coil-tubing, CTU, well-cleaning, abandonment, scale, contact energy, western energy

ABSTRACT

Geothermal generation projects are capital intensive and other renewables are seeing continuously decreasing levelized cost of electricity (LCOE) on a large scale. In order to stay competitive, geothermal operators need innovative and cost-effective solutions to maintain production and defer the large capital costs of new wells. The failure, decline, or interruption of a well can have a significant impact on individual well production and station output. The challenges presented by down-hole issues in geothermal wells requires innovative solutions to maintain cost competitiveness of geothermal energy. This paper discusses some of the significant improvements we have made to geothermal well intervention and highlights the process and client/contractor partnership that enabled these advancements.

In New Zealand, Western Energy has pioneered the application of coiled-tubing intervention (CTU) in geothermal wells for operations that previously were the exclusive domain of drilling rigs. Western has demonstrated significant value to geothermal generation companies using CTU's in well abandonments, fishing operations, acid stimulation, well initiation and mechanical scale cleanouts. This has resulted in achieving operational goals at significantly lower cost, reduced generation downtime and improved effectiveness. Two examples of Western's innovation are: 1) well abandonments, where a step-change in process and continuous improvement initiatives have combined to provide effective abandonment of wells at 75% less cost than previous rig-based solutions, and 2) scale cleanouts, where our new Live Well Cleanout method enables scale cleanouts to occur with the well flowing, minimizing production downtime and maximising cleanout efficacy, coupled with an order of magnitude reduction in cost.

A critical factor in the success of these innovations has been the effective client-contractor partnership between Western Energy and Contact Energy Limited. The development of new approaches and technology were enabled by and significantly enhanced by, the collaborative working relationship, shared goals, long-term approach and innovative contracting models. Western continues to look for new opportunities to bring step-change to geothermal well operations and welcomes the challenge to deliver more innovation and value for geothermal operators.

1. INTRODUCTION: GEOTHERMAL ENERGY NEEDS INNOVATION

Geothermal energy is under constant cost pressure from both strategic and market forces. Around the world, countries are moderating emissions from power generation to benefit both local air-quality and global climate. In addition, countries are implementing strategies to substitute electricity for fossil fuels in industrial use and transportation (de-carbonisation).

As a result, the electrification of world's economies is increasing along with the demand for reliability, resiliency, and affordable prices. As electricity becomes more essential to the functioning of societies, the downward pressure on costs will only increase. To thrive in the future, geothermal energy must provide both performance and lower cost.

In the tactical battle between renewable energy alternatives, geothermal energy growth lags intermittent renewables, particularly solar and wind considerably (Figure 1). This reflects the precipitous decrease in cost enjoyed by solar PV and onshore wind within the last decade. IRENA (2019) reports a 77% drop in the levelized cost of electricity (LCOE) from Solar PV from 2010-2018, with a 13% drop in 2018 alone. The costs of onshore wind development, as well as other renewables such as bioenergy and concentrated solar power declined similarly. During the same period, IRENA records that the costs for developing geothermal increased slightly.

Consequently, the pressure to reduce costs makes Well Services an increasingly core capability for geothermal field operators.

Drilling typically consumes between 30% and 50% of the up-front capital costs of development (Thórhallson and Sveinbjornsson, 2012). In addition, drilling commonly devours much of the capital required to sustain existing geothermal operations. Drilling rig costs have become particularly acute for geothermal operators in locations without sustained drilling operations. Operators are therefore increasingly focused on the availability, performance, and longevity of their existing wells.

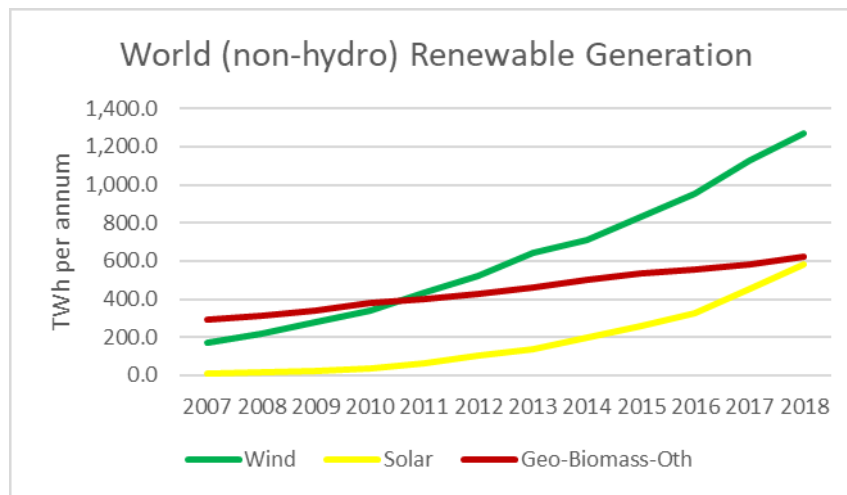


Figure 1: Wind, Solar, Geothermal and Other Renewable Generation. Source: BP Statistical Review of World Energy 2019

The key services contributing to well performance and capital efficiency comprise:

- Production and injection well performance monitoring (mass flow, WHP, WHT, reservoir pressure, reservoir enthalpy, reservoir temperature, fluid chemistry) and controls;
- Production process controls: (pumps, chemical inhibition and dilution systems);
- Field performance monitoring (tracer tests, fluid and NGC chemistry, monitor wells);
- Well condition monitoring (CBL logs, calipers); and
- Well interventions: clean-outs, casing repairs, stimulations; plugging and abandoning.

This paper provides a New Zealand case study of significant reductions in well maintenance costs resulting from collaboration between a geothermal operator and well services company. Under a partnership arrangement, Contact Energy and Western Energy Services have developed new techniques for the removal of wellbore scale and well abandonments; these have resulted in material operational savings.

2. AN ORDER OF MAGNITUDE COST REDUCTION IN REMOVING WELLBORE SCALE

Contact Energy experienced serious difficulties in economically removing mineral scale from within geothermal production and injection wells. The historical approach had been to employ a workover drilling rig, quench the well and remove pipework connections, mobilize the rig, conduct the workover, leave the shut-in well to heat up, test and reinstall the wellhead connections, and finally return the well to service. This process typically took 2-3 weeks but some wells took more than double that time, costing several million NZ dollars in direct costs and lost generation.

A solution was urgently needed; Contact Energy engaged with Western Energy to find a solution. Initial approaches included wireline broaching (Wilson et al, 2014) but the transformation came with Western Energy's introduction of coil tubing cleanouts in 2014 (Wilson et al 2015). Through 5 years of iteration and innovation the partnership:

- developed a clean-out process that removes wellbore scale while the well is flowing;
- reduced the outage time from weeks to hours;
- decreased the technical risks of clean-outs;
- refined the process to recover all scale from the wellbore to avoid formation damage; and
- reduced the direct cost of a clean-out by half.

In the process this has turned a major intervention process into a routine maintenance activity. The partnership has now cleaned out more than 30 wells; this has improved steam production, increased plant capacity factors, and deferred the drilling of at least two replacement wells. A companion paper at this World Geothermal Congress (Wilson & Anderson, 2020) describes the technical evolution and development of the Live Well Cleanout operation.

3. CLEANOUTS BETWEEN BREAKFAST AND DINNER

In New Zealand, as in other temperate climates, electricity loads peak in the morning and evening. While the country generates 84% of its electricity from renewables, in winter the demand peaks are out-of-phase with solar PV and commonly wind. The secure 17% baseload provided by geothermal energy allows hydro generation to swing production into these peak periods, reducing system costs. However, every geothermal MW that is unavailable increases the probability that fossil fuel generation will be dispatched to meet demand.

The Live Well Cleanout process now enables a geothermal well to be cleaned out in a single day, between the morning and evening demand and price peaks. This feature preserves and enhances the well productivity over peak demand periods. Clean-out operations are finely scheduled to run-in-hole as soon as the morning peak has subsided, clean the well of scale, pull out-of-hole, and return the well to service in time for the evening peak. Therefore, the benefits of increased generation are instant and outage time minimized, further decreasing the total cost.



Figure 2: Western Energy live well cleanout operations on a well at Contact Energy's Wairakei Field in New Zealand

4. HALVING THE COST OF WELL ABANDONMENTS, AND THEN HALVING THEM AGAIN

Geothermal balance sheets necessarily include provisions for abandoning wells. Operators such as Contact Energy monitor the casing condition of their geothermal wells and repair or plug any wells that pose a significant technical or environmental risk. Wairakei Geothermal Field contains over 300 wells, with vintages from the 1950s through 2015. Many of the old wells were obsolete or posed a risk; Contact Energy needed an efficient abandonment method to address these risks while enabling focus on improving production. The partnership, using Western Energy's coil tubing services, developed a procedure for well abandonments that enabled a step-change lowering of costs (50% reduction in \$/m abandoned) from previous rig-based methods.

This meant challenging all aspects of the abandonment process, from technical requirements, reservoir and cased-hole section approaches, cementing and cement design, and pad and cellar remediation. In some cases, well obstructions required additional well works to enable well access before cementing operations could proceed.

This emergence of new methods illustrates how the innovative use of Coil Tubing is stimulating improvements in well interventions and operations. This equipment exhibits a range of capabilities and efficiencies not matched by work-over rigs. Western Energy Services remains committed to bringing this service to the industry.

5. PARTNERSHIP AND COMMERCIAL INNOVATION WERE ENABLERS

Technical innovation flourishes atop a firm commercial/organisational foundation. The cost drivers for change and innovation in New Zealand are relentless. For a geothermal operator the cost of energy and the cost to deliver to the customer must decrease, as a business performance fundamental and to enable decarbonization through the economic substitution of renewables for fossil fuel generation. In response to this challenge, Contact Energy and Western Energy Services decided to jettison the historical "pricing power" model of well services, so prevalent in the oil and gas industry, and experiment with a new approach. These arrangements accommodated technical and commercial risks between the parties, thereby fermenting a shared vision to transform well interventions into routine maintenance.

Both parties contributed unique attributes to the enterprise. Contact Energy were prepared to try alternative well services options in their high-value wells, and retained an appetite to persevere despite multiple initial failures. Similarly, Western Energy, uniquely for a service company, promoted risk-reward based contracts for the first phase of intervention trials where failure resulted in no revenue to Western. This partnership overcame many failures but achieved sufficient wins to sustain an appetite on both sides to invest in the development of tools and process, keeping the innovation process alive. The innovation was not simply technical but also commercial and managerial, befitting a genuine client-service company partnership.

6. CONCLUSION: A GAME CHANGER FOR THE GEOTHERMAL INDUSTRY

Our story comprises an operator, Contact Energy, with a need and desire to solve a long-running problem: the high cost of well clean-outs and abandonments; and a contractor, Western Energy Services, with an equivalent desire and drive to solve it. However, needs and desires alone do not deliver solutions. Innovation is a long and iterative journey, which needs a process, funding, risk appetite and collaboration to maintain cadence and momentum. The unique relationship between an operator prepared to apply innovation to its operations with the appetite for trial and error over the long term, and a service company prepared to experiment, to share risk, and to approach innovation with an evolve-or-die assertiveness has delivered some compelling game-changers for the geothermal industry.

REFERENCES

- IRENA (2019) Renewable Power Generation Costs in 2018, International Renewable Energy Agency, Abu Dhabi.
- Thórhallson, S., and Sveinbjornsson, B. (2012): Geothermal drilling cost and drilling effectiveness. Short course on Geothermal Development and Geothermal Wells organized by UNU-GTP and LaGeo, in Santa Tecla, El Salvador, March 11-17, 2012. 10
- Wilson, D., Gilliland, J., Austin, A. (2014) Broaching: An Effective Method of Well Intervention for Calcite Scale Removal, 36th NZ Geothermal Workshop, Auckland, New Zealand
- Wilson, D., Aranas, M., Bixley, P., Anderson, J., Patterson, D. (2015) Application of Coiled Tubing for Live Well workovers, 37th NZ Geothermal Workshop, Taupo, New Zealand.
- Wilson, D. & Anderson, J. (2020) Coiled Tubing Live Well Cleanout, Proceeding World Geothermal Congress 2020