
PHOTO: PETROSPEC ENGINEERING

# Momentum builds for in situ electrical heating as commercial viability confirmed

By Scott Penny, Chase Hartwell and Barry Lappin, Petrospec Engineering

The current downturn in commodity prices creates not only the opportunity but the necessity for innovation. In this environment, new megaprojects or large expansions are in question, especially in Alberta's relatively high-cost oilsands. It is clear that a paradigm shift is necessary, and this has spurred a closer look at the next generation of transformative technologies. With large-scale investment harder to come by, industry will increasingly look to either take smaller bites or optimize current operations.

Many efforts have been made to look for suitable economic alternatives to steam injection for heavy oil production. The sourcing, treating, heating and handling of large volumes of water is a relatively expensive process that comes with undesirable environmental impacts. Some of the more promising new technologies are electric heat, solvent injection or a combination of the two. Downhole electric heating offers a number of potential solutions, many of which are suitable for modular application and production optimization.

Electric heating describes any process that delivers heat, converted from electricity, to the reservoir allowing for more efficient and economic production. For SAGD projects, this may mean earlier and more evenly distributed heat on SAGD start-up, eliminating steam for infill wells or improving steam quality.

Advances in high-watt electric heating might also unlock new reserves such as shallow or thin pay reservoirs currently deemed uneconomic with SAGD. Additionally, Alberta is currently experiencing severely depressed electricity generation prices (see Figure 1), which suggests that SAGD cogeneration infrastructure is underutilized. This creates an opportunity to better leverage that energy by delivering it downhole to produce more oil and potentially free up steam capacity.

The application of downhole electric heating may have numerous environmental benefits as the process reduces water requirements along with the potential to decrease greenhouse gas emissions for project proponents applying the technology.

The applications for electric heating vary depending on the reservoir as well as the technology applied.

Generally speaking there are two flavours of electric heating. The first is a low-watt process suitable for heating relatively short sections with minimum reservoir penetration. These systems are particularly well suited to reduce oil viscosity near the pump and increase pump efficiency for heavy oil or waxy oil production. The second is a high-watt process that delivers significantly more energy over a longer section. This is more suitable for horizontal wells and reservoirs that require heating an appreciable distance into the reservoir.

Cold heavy oil production with sand (CHOPS) optimization and post-CHOPS applications are possible with low-watt technology but may be improved with higher-watt schemes. Higher-watt technologies allow for more complex heat propagation regimes in addition to conduction, such as convective heating and refluxing fluids. High-watt heater elements have been used to pre-heat the reservoir surrounding both SAGD producers and injectors during the start-up process. ▶

## O&G REGULATED ELECTRICITY RATES

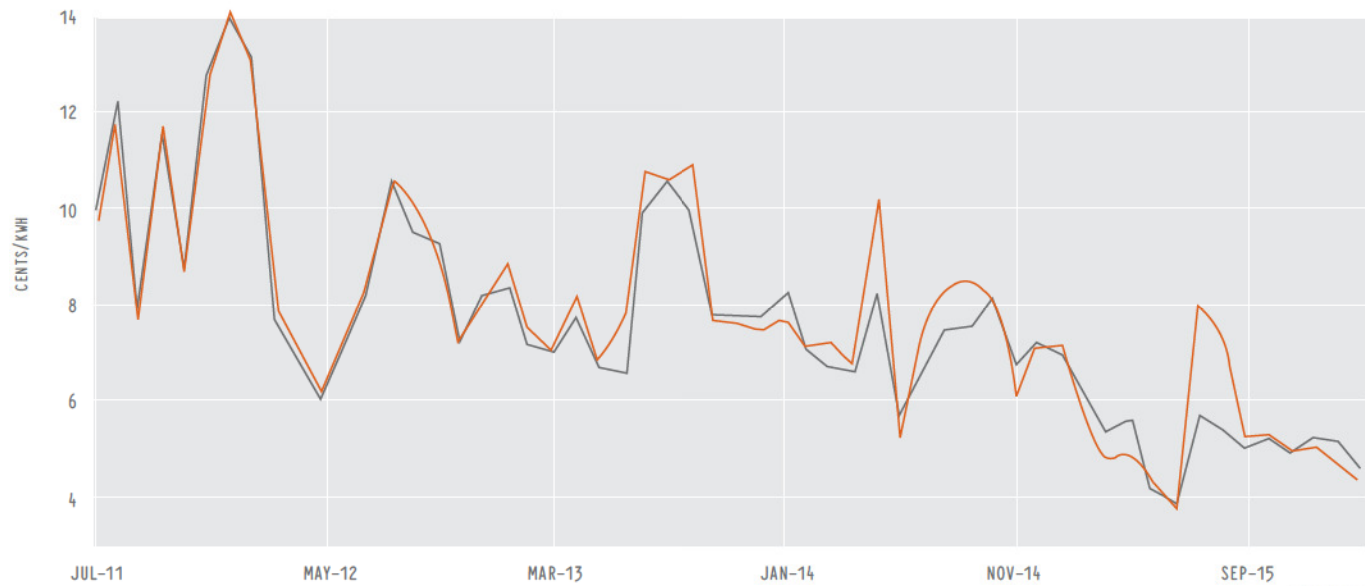


FIGURE 1

## SCHEMATIC OF ELECTRIC HEATING SYSTEM

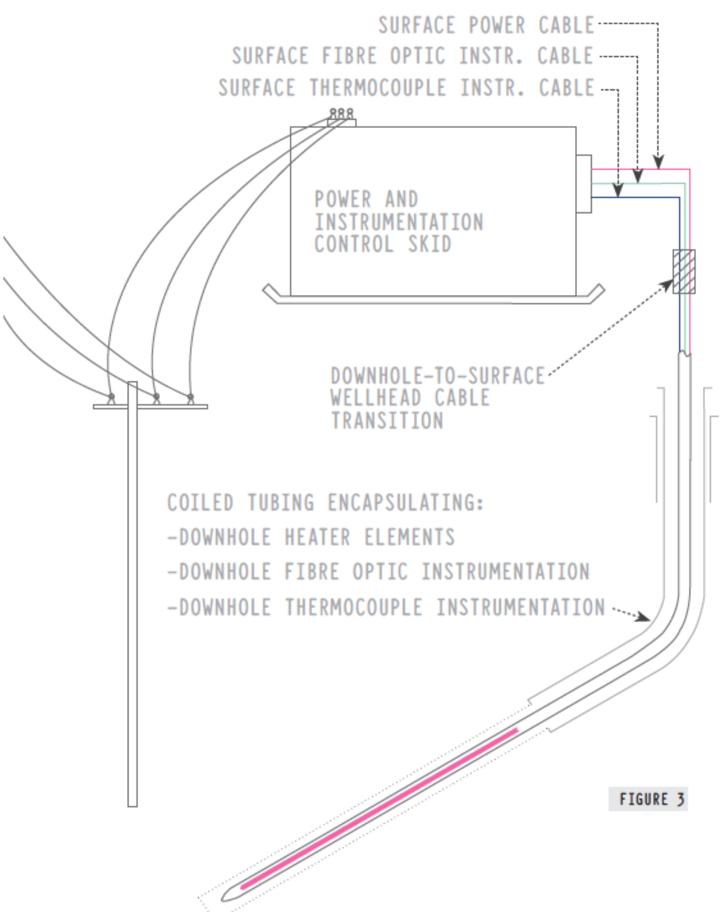


FIGURE 3

This reduces or even eliminates the need for a circulation phase to achieve communication between the injectors and producers.

Low watt–density systems (up to ~100 W/m) have been deployed using resistive heating elements in many different downhole configurations. The most common deployments use a stainless sheathed cable with a coaxial conductor electrically insulated using mineral powder, fibreglass or even high-performance polymers. The smaller diameter cables typically have a rating of less than 1,000 volts and are therefore limited in capacity. The two most common systems are either a simple resistive element or what's known as a "skin-effect" heater. The resistive element is typically comprised of a modified heat trace cable spliced end to end. The skin-effect heater uses a copper core and frequency modulation to deliver heat downhole. The modulating power supply takes advantage of the tendency of alternating current to become preferentially distributed near the surface of the conductor causing the effective resistance to increase.

There have also been recent advancements in multi-conductor technology, which offers a flexible, cost-effective, higher-capability system to suit a variety of needs. These low-power systems allow electric heating to be applied at a lower capital cost and in certain applications offer the best return on investment.

High watt–density electric heating systems (up to ~1,000 W/m) use stainless steel–sheathed mineral-insulated elements encapsulating a single conductor of copper transitioning to a resistive alloy for the heated section without the use of an external splice. This is a truly splice-free heater element available in lengths suitable for extended-reach horizontal wells. High watt–density electric heating systems deliver considerably more energy to the reservoir and offer the most promise in terms of a complete reservoir stimulation process. Historically, these systems have been relatively costly and have not proven reliable enough to operate over long periods of time. With the latest advancements in technology, electric heating cables now have longer lifespans and costs are expected to fall once commercial volumes are achieved.

Electric heating elements can be either strapped to the outside of tubing or packaged inside of coiled tubing. Petrospec Engineering prefers the coiled tubing option as it offers several advantages including ease and speed of deployment, protection of components to enhance reusability, and integration of temperature and pressure monitoring.

An inherent benefit of this design that is often overlooked is that the coiled tubing distributes the heat over a larger surface area, which helps reduce coking and thermal runaway failures compared to exposed heating elements clamped to the outside of the tubing. Coiled tubing deployment also allows for integrated injection lines for adding solvents or other fluids from one or many ports along the wellbore.

## EXAMPLE OF DTS HEATER DATA

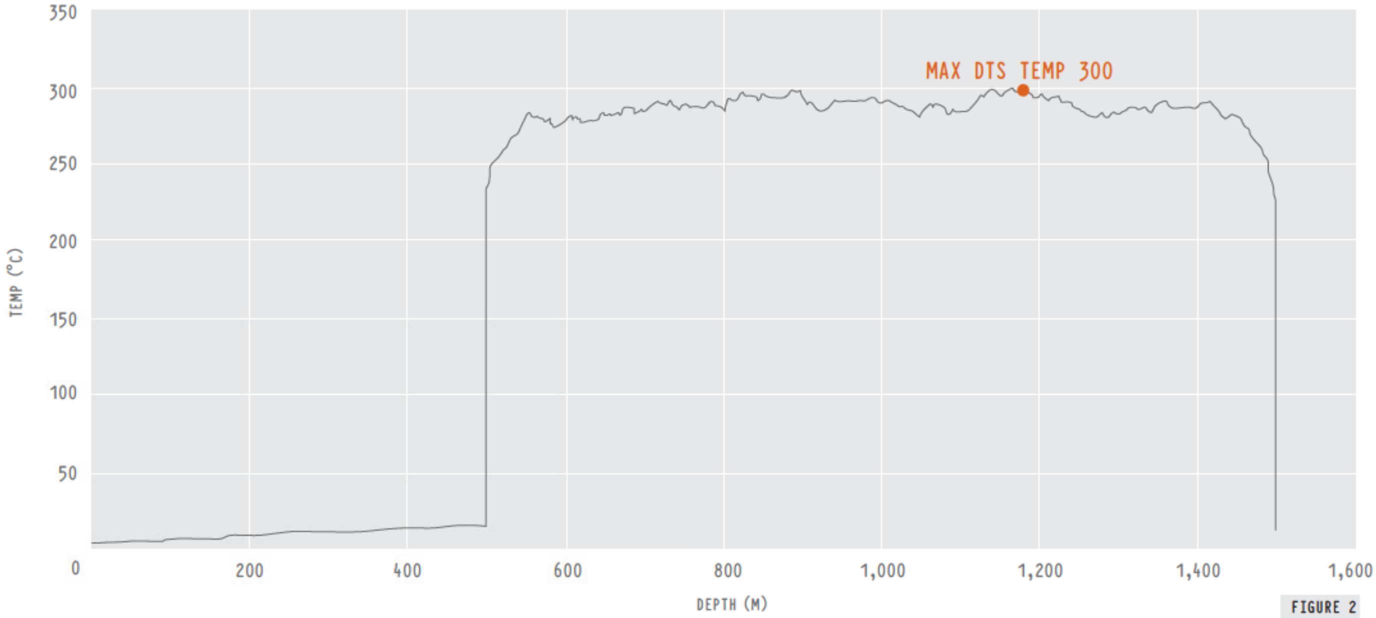


FIGURE 2

Preferably the coiled tubing will include DTS fibre optics for temperature monitoring and heater control. The fibre optics provide continuous distributed monitoring immune to the electrical noise of the heater operation. This gives the operator full control and allows the heater to be tuned to the application. Data visualization tools included with the fibre optics are critical for the operator to interpret the information being collected. Packaging the heating elements and instrumentation together improves the reliability of the electric heating system.

A significant benefit of coiled tubing packaged electric heating elements is that it allows electric heating technology to be installed with conventional coiled tubing units. Recently completed projects have demonstrated the tremendous efficiencies obtained during on-site installation of a single coil deployed system, and additional efficiency gains will be realized when multiple systems are installed at the same time.

The surface power and control package drives the downhole electric heating technology. A significant advantage of electric heating systems is the ability to instantly and precisely control the amount of energy applied directly in contact with the reservoir. Control packages can be skid deployed and include commercially available components, such as drives and transformers, in combination with proprietary control modules.

Control modules allow easy operation of power adjustments and can be pre-programmed for ease of operator use, including ramp up and ramp down. Every project has its own unique set of requirements including available power, well depth or wattages, and a "one size fits all" approach is not cost effective.

Electric heating alone does not have the same extended reach into the reservoir as steam; however, the ability to start up SAGD wells with an even heat profile from heel to toe is extremely beneficial. An ideal heat distribution on start up over the horizontal length of a SAGD well can add significant oil productivity over the life of the well. Although not proven on a commercial scale to date, the addition of a solvent to an electric heating system should considerably improve the effective production zone of the wells.

Many SAGD operators have already drilled infill wells to increase recovery while numerous other projects are in the planning or pre-planning phases for the same. In some cases, these infill wells can go straight to production, but usually a steaming period is required. The infill wells must therefore be completed and equipped with surface steam lines, diverting steam from other pads.

The application of downhole electric heating solves this challenge, warming the infill well without having to drill larger wells or complete them for steam injection. Perhaps more importantly, heating infill wells with electric heat may allow operators to expedite their plans and put infill wells on production much earlier. As electric heating technology matures, there is an ever-expanding list of potential applications in which electric heating provides significant technical and economic benefits.

A skid-mounted surface control package along with coiled tubing–deployed downhole equipment provides a mobile, modular system that can be redeployed in multiple wells. Petrospec Engineering has installed numerous electric heating systems over the past decade, culminating in a pre-commercial technology and design methodology specifically for SAGD applications.

In late 2015, Petrospec's commercial-style system, called Hot-Tube, was built, installed and operated in a SAGD well. In 2016, this system was successfully retrieved from the well without damage and is ready for re-installation. The system proved reliable in generating over 600 W/m throughout the horizontal heated section. This system was designed to be reproducible on a commercial scale while retaining the flexibility to customize the system to the individual well and application. This installation confirmed the commercial viability of both the base electric heating technology and the design methodology employed.

Downhole electric heating technology is now beyond the pilot phase and is commercially available with the potential to benefit many different reservoirs in many different applications. Power consumption for high watt–density systems can become quite substantial (roughly 0.5 to 1.0 megawatts per well) particularly if multiple systems are installed. However, in projects where cogeneration is already present the economics are greatly improved as cogeneration can offset a significant portion of the op-ex costs. Electric heating can also unlock reserves previously inaccessible or uneconomic with conventional recovery techniques. As deployments of downhole electric heating technology become more frequent, the technology is finding usefulness in ways never before imagined.

*Petrospec Engineering is a boutique engineering firm in Sherwood Park, Alta., specializing in delivering turnkey reservoir monitoring and production optimization solutions to heavy oil operators worldwide.*

*Over the past decade, Petrospec has dedicated tremendous resources to tackle the engineering and operational challenges faced with implementing downhole electric heating including access to a decommissioned air force runway providing a fit for purpose facility ideal for integrating multiple technologies inside coiled tubing.*