Spotlight on Women in Geothermal USA- March 2024

Cindy Taff, CEO of Sage Geosystems

New generation geothermal exploration mirrors an uncharted frontier, where pioneers tirelessly work to unravel the complexities of reducing the Levelized Cost of Energy (LCOE) generated from geothermal power plants. At the forefront of this effort is Cindy Taff, leading the charge at Sage Geosystems, a North American startup headquartered in Houston, Texas.

From Oil and Gas Executive to Geothermal Startup

What sets Sage Geosystems apart from other players in the geothermal sector? It is the makeup of its leadership team, which consists of former executives from the Oil and Gas industry. Notably, Cindy brings a wealth of expertise from her previous role as the VP of Unconventional Wells & Logistics at Shell.

During her remarkable 35-year tenure at Shell, she successfully managed a billion-dollar business unit, overseeing a team of 350 employees and 1200 contractors. Cindy's career trajectory, transitioning from an individual contributor after twelve years to holding significant managerial roles like VP of Wells Discipline and General Manager of Wells Operations & Engineering, underscores her depth of experience and leadership acumen in the field.

With each step up the corporate ladder, when Cindy transitioned to a new role, her former position would typically be filled by two individuals. This highlights the high energy and focus that Cindy brings to the table.

It's not unexpected to discover that Cindy would proactively seek out opportunities to work in the field during her time as an engineer with

Sage's Representation Initiatives

Cindy Taff is actively addressing representation in the geothermal industry. In 2023, she engaged female students from a Houston high school to explore strategies for increasing female participation in the geothermal sector. The students' findings were subsequently shared with various geothermal organizations to solicit their assistance in promoting gender diversity within the field. These efforts are ongoing.

Cindy emphasizes that to enhance the pipeline of females in STEM fields at the college level, it's crucial for the industry to direct attention towards middle school students, guiding them towards an early focus on STEM subjects throughout high school.

Furthermore, Cindy is committed to fostering a diverse workforce as Sage expands.

Work Life Balance

Outside of work, Cindy enjoys spending time on her ranch with her horses, riding four wheelers and tractors!

Shell. Possessing a hands-on mentality, she recognized the significance of fieldwork—a chance that all too few women in the energy industry are afforded.

Cindy found inspiration to shift from the oil and gas sector to geothermal energy through her former colleagues at Shell and the visionary founders of Sage Geosystems, Lance Cook and Lev Ring. Renowned for their technological innovations, Lance and Lev, pioneers of expandable casing at Eventure, often introduced Cindy to cutting-edge offshore technologies for testing in her onshore assets. Impressed by their vision and convinced of their breakthrough in cost-effective geothermal solutions, Cindy was receptive to Lance and Lev when they approached her to join their team at Sage. In late 2020, Cindy parted ways with Shell and transitioned to Sage at the start of 2021, becoming the fourth employee.

Learning to Harvest Heat and Pressure Effectively from The Reservoir

Sage secured its initial funding in 2021 and swiftly initiated a pilot project. This endeavor involved reentering a gas exploration well previously drilled by Shell in 2008, which had turned out to be dry. Consequently, Shell hadn't run the final casing string, leaving the well with a 9 5/8-inch casing that extended all the way to a depth of 12,000 ft, an uncommon occurrence in onshore oil and gas operations. Recognizing its potential for geothermal utilization given the large casing size, Sage reentered this well and created a large downward-oriented gravity hydraulic fracture and then spent four months operating the fracture to learn how best to harvest the heat cost effectively.

Unlike typical EGS injector and producer wells, which often require substantial horsepower for circulating geothermal brine through hydraulic fracture networks, Sage's approach seeks to optimize horsepower requirements, affording a more cost-effective solution to generate electricity, by operating a fracture in a single well in a low permeability zone, akin to keeping a balloon full of air and notably without the use of proppant.

The objective is for the fracture, created with a fluid resembling a drilling mud, to remain open by monitoring the fracture signature pressure, maintaining a pressure range between the fracture opening and fracture extension pressures. Operating the fracture in this manner offers another advantage in addition to reduced friction losses, the entire fracture area can be leveraged for heat transfer. This stands in contrast to a propped fracture, which might experience closures in specific regions, leading to water following paths of least resistance and potential channeling, resulting in cold-water breakthrough.

Moreover, Sage adopts a mathematical approach when aiming to reduce LCOE of the geothermal system by leveraging both the pressure and heat energy in the downhole working fluid. Considering the enthalpy equation, which encompasses internal energy (heat) in addition to pressure multiplied by volume, Sage recognizes that many technologies solely focus on the heat aspect in geothermal analysis. However, leveraging pressure to generate electricity yields greater efficiency compared to converting heat directly into electricity. Thus, disregarding pressure could result in the loss of 25 to 50% of the net output.

Sage has coined their geothermal systems Geopressured Geothermal Systems (GGS), which leverages the pressure and heat from the subsurface. Sage pursues reservoir temperatures of 120°C or lower at depths of 7,000 – 12,000 ft for geothermal storage to prevent two-phase flow in their Pelton turbines. Conversely, for geothermal power generation, which leverages both pressure and heat, Sage targets reservoir temperatures of 150°C or above at depths of 14,000 ft or greater.

Accomplishments of 2023: Pairing Energy Storage with Solar Power

Cindy's major achievements at Sage in 2023 involved overseeing the successful implementation of a full-scale commercial pilot for energy storage. Sage constructed a 30,000-barrel water storage facility and conducted repeated water cyclic operations into their well, monitoring surface rates and pressures to determine output capacity and measuring storage durations in proportion to volumes cycled, the primary goal of the pilot.

Sage conducted an experiment to illustrate the synergy between GGS storage and solar power in supplying uninterrupted electricity throughout a 24-hour cycle. Brine injection into the subsurface reservoir storage for seven hours enabled electricity generation for the subsequent 17 hours, simulating the utilization of solar power during the initial seven hours and GGS for the remaining duration.

Over the 17-hour period, water passes through a choke manifold to regulate the flowback, enabling prolonged production. Subsequently, all water was rapidly released from the fracture over a one-hour period to showcase load-following capability of GGS. Sage aimed to demonstrate their capacity to meet peak demand during Texas summers. Their system was meticulously modeled to ensure their wells could each deliver 3 MW of power during these peak hours.

Future Endeavors: Sage Geosystems' Expansion Plans

Cindy's primary goals for 2024 entail commissioning a new facility, complete with a newly drilled well, wellhead, and Pelton turbine, with the aim of storing and supplying electricity to the ERCOT grid by December. Sage will be looking to develop their systems in Texas, California, Louisiana, Middle East, and Europe.

In 2025, Sage intends to deepen their Starr County well as part of a collaboration with the USA Military, transforming it into a geothermal well using their GGS technology to harness both heat and pressure, rather than solely focusing on geothermal storage, which primarily utilizes pressure. This project will involve the implementation of a binary cycle turbine alongside a heat exchanger at the geothermal power plant, departing from the Pelton turbine typically used in conjunction with geothermal storage. Demonstrating geothermal storage was a targeted first step in their technology demonstration, before tackling demonstration of the more complex geothermal power generation. Geothermal power generation LCOE still needs to be reduced to be competitive on the Texas market, and Sage is working to address this.

Initiatives to Reduce the LCOE of Geothermal Power Generation: New Supercritical CO2 Turbine

To reduce the LCOE in geothermal power generation, Sage is concentrating efforts in optimizing the power generation facility, particularly the choice of turbine. The Organic Rankine Cycle, typically employed in low enthalpy geothermal operations, achieves an efficiency in converting heat to electricity of only 8-10%. Consequently, Sage has collaborated with the Southwest Research Institute to design and build an innovative small footprint supercritical CO_2 turbine, aiming to achieve an enhanced efficiency ranging between 15% to 20%. This turbine will operate at temperatures of 250°C and pressures of 3500 psi, representing a significant strategy for Sage in lowering the LCOE of geothermal power generation.

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