Ten lessons about Electrical Submersible Pumps (ESPs)

Reliable, safe and cost efficient ESPs in geothermal applications

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Following earlier successful editions on well testing and avoiding sidetracks, EBN and Geothermie Nederland organized another technical workshop dedicated to Electrical Submersible Pumps (ESPs) in geothermal applications. Around thirty participants from the Netherlands and Germany gathered for an interactive program focused on sharing practical experience, technical challenges, and possible solutions. The audience consisted of operators, contractors and ESP specialists. To share their knowledge and insights with the community we present ten key lessons from this workshop.

ESPs are electrically driven downhole pumps that provide artificial lift to bring fluids to the surface. Although they are a mature technology in the oil and gas industry, conditions during geothermal operations place them under stresses they were not originally designed for. Conditions like high flow rates, high temperatures, and thermal cycling (due to the systems operating at reduced capacity for part of the year) can lead to accelerated wear and failure. Given the high cost and operational impact associated with ESP failures, sharing knowledge and experiences on this topic throughout the industry is important.

The workshop made clear that ESP reliability in geothermal applications is never determined by just one single factor. Design, installation, operation, monitoring, and organizational practices are all connected. Quality reduces cost on the long term, monitoring enables insight, and collaboration accelerates progress. With coordinated effort and shared learning, the sector can significantly extend ESP lifetime and reduce operational costs. The ten lessons gathered here provide insight, the collective challenge now is to act on them as a sector.

EBN would like to thank Geothermie Nederland for their collaboration in preparing the ESP workshop.

1: Root cause analysis must be standard practice

While ESP performance in geothermal applications has improved over time, failure variability remains high. A major reason for this is the lack of consistent root cause analysis and standardized failure reporting. The workshop highlighted that without systematic investigation and shared learning, the same mistakes are repeated multiple times and across projects. Each ESP failure represents a learning opportunity, but only if data are collected, analyzed, and made accessible to the sector. Participants agree that they are open to collecting and sharing these data as much as possible.

2: Installation quality determines lifetime

The installation phase was repeatedly identified as one of the most critical stages in the ESP lifecycle. Limited straight sections in geothermal wells, compromises made between well design and pump requirements, and insufficient alignment control can all introduce hidden stresses on the ESP. These issues often go unnoticed during the commissioning phase but may lead to premature failure of the ESP months later. To prevent this, strict procedures, adequate preparation time, and well trained system operators were highlighted as essential measures to reduce preventable failures.

3: Thermal cycling is a silent degrader

Unlike oilfield ESPs that often operate under stable conditions, geothermal systems experience strong seasonal and also operational variability. Changes in flow rate and frequent start-stop cycles induce thermal shocks in motors, seals, and cables. Over time, these thermal stresses accelerate material fatigue and degradation of the different components of the ESP. The experts emphasized that geothermal operating must explicitly account for these cycles through careful ramp-up and -down strategies and conservative operating windows.

4: Electrical settings and VSD configuration matter

Several speakers demonstrated how incorrect Variable Speed Drive (VSD) settings and electrical configurations can significantly shorten the ESP lifetime. Inappropriate startup parameters, poorly tuned overload protection, and insufficient grounding can lead to cable damage, unstable sensors, or delayed emergency shutdowns during critical events. Gas decompression in cables during rapid pressure drops was identified as a particularly destructive mechanism. Electrical design and commissioning were therefore recognized to be as important as mechanical integrity.

5: Vibrations and dynamic loads are often underestimated

An interesting insight from the workshop was the role of vibrations and dynamic loading that can occur. ESPs and production strings behave as complex oscillating systems, yet the existence of these dynamics is frequently neglected in design and operation. Differences in stiffness between large-diameter tubing and slimmer pump sections can create natural resonance points. Even minor vibrations can accumulate over thousands of operating hours, resulting in cracked flanges, deformed housings, and bearing failures. Avoiding resonance frequencies and monitoring vibrations during operation and testing were identified as key reliability measures.

6: Data, sensors, and AI are becoming essential

Advances in digitalization were presented as a possible turning point for ESP reliability. Traditional monitoring that is based on things like voltage, and flow provides only limited insight. New technologies like acoustic sensors, fiber-optic measurements, and advanced signal processing enable early detection of instability, wear, and abnormal loads. Machine learning techniques already show the potential to predict failures days or weeks in advance, allowing for planned interventions instead of reactive shutdowns that have economic implications for the project.

7: Higher quality materials reduces total cost

A central question during the workshop was whether ESP lifetime can be extended without increasing costs. The consensus was clear: focusing solely on capital cost creates a misleading picture. This is because in geothermal operations, it's the operational costs that dominate due to the lifetime of the projects. Investments in better materials, improved monitoring, and stricter procedures will therefore typically result in a pay-back of the initial investments by avoiding unplanned downtime and costly workovers. Quality, the participants concluded, is not a cost driver but a cost reducer.

8: Geothermal ESPs require purpose-built design and assembly

Geothermal ESPs differ fundamentally from those used in oil and gas production. Higher flow rates and larger lift requirements result in larger and heavier pump systems. The assembly processes and procedures must be adapted to accommodate the larger equipment. During equipment sizing, protector oil volume calculations in geothermal ESPs must also account for significantly larger temperature fluctuations. These fluctuations arise from the relatively shallow depths of geothermal ESPs compared to those used in oil wells, which are typically closer to the reservoir. Because geothermal brine, unlike oil, offers limited natural lubrication, components like spiral-groove bearings become essential to maintain operational stability. Geothermal ESPs therefore require dedicated engineering and assembly practices.

9: Standardization and collaboration enable progress

Although every geothermal well is unique, the workshop identified significant opportunities for standardization. Particularly in procedures, monitoring, and the surrounding systems. The relatively small and fragmented geothermal market does not have the scale to drive innovation individually. That is why we need stronger collaboration between operators, supported by organizations such as EBN, Geothermie Nederland and TNO that is reinforced through international cooperation. This is essential to create unified demand and stimulate geothermal-specific ESP development.

10: The sector is willing to share data and knowledge

The final lesson is looking forward. Improved operational discipline has already led to longer ESP lifetimes, demonstrating that meaningful improvement is achievable. However, sustainable progress requires collective commitment. Suppliers need clear, consistent specifications, operators must share data and lessons learned, and the sector must invest in knowledge platforms and technology development. The workshop concluded with a strong sense that the geothermal sector is absolutely ready for this new phase. This marks the starting point for possible next steps. Several parties, including EBN and Geothermie Nederland, will now explore how these lessons can be further shaped and embedded in the sector.