Well completion of suspended and abandoned wells for the production of thermal and electrical energy

Marija Ilic, Dušan Danilović, Miroslav Crnogorac, Vesna Karović-Maričić, Lola Tomić, Anastasija Mirjanić

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WELL COMPLETION OF SUSPENDED AND ABANDONED WELLS FOR THE PRODUCTION OF THERMAL AND ELECTRICAL ENERGY

Marija Ilić[1], Dušan Danilović[1], Miroslav Crnogorac[1], Vesna Karović-Maričić[1], Lola Tomić[1], Anastasija Mirjanić[1]

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Abstract: Suspended and abandoned wells present a considerable opportunity for renewable energy production, whether in the form of thermal, electrical, or combined energy. By utilizing existing infrastructure to harness these forms of energy, it is possible to reduce negative environmental impacts while simultaneously increasing energy efficiency and sustainability. This approach contributes to reducing dependence on fossil fuels and promotes the development of technologies based on renewable energy sources. Suspended wells offer the advantage of being immediately ready for use when needed, making them an efficient solution. In this paper, completion of suspended and abandoned wells for the production of thermal and/or electrical energy is presented.

Keywords: well completion, suspended well, abandoned well, thermal energy, electrical energy

1 INTRODUCTION

Wells whose production is no longer economically viable are either suspended or abandoned. (Templeton et al., 2014). Due to their depth, which ranges from 1000 m to over 2000 m, such wells reach the warmer layers of the Earth's crust (Milivojević, 2011) and represent a significant untapped geothermal potential (Ilić et al., 2023, Jandroković,2021). Suspended and abandoned wells present a considerable opportunity for renewable energy production, whether in the form of thermal, electrical, or combined energy. By utilizing existing infrastructure to harness these forms of energy, it is possible to reduce negative environmental impacts while simultaneously increasing energy efficiency and sustainability. This approach contributes to reducing dependence on fossil fuels and promotes the development of technologies based on renewable energy sources. Depending on the temperature at the bottom of the well, suspended and abandoned wells

[1] University of Belgrade - Faculty of Mining and Geology, Djušina 7, Serbia

E-mails: marija.g.ilic@rgf.bg.ac.rs ORCID 0000-0002-5184-6685; dusan.danilovic@rgf.bg.ac.rs ORCID 0000-0002-2969-040X; miroslav.crnogorac@rgf.rs ORCID 0000-0002-8078-2684; vesna.karovic@rgf.bg.ac.rs ORCID 0000-0002-6323-1311; lola.tomic@rgf.bg.ac.rs ORCID 0000-0002-6107-1780; anastasija.mirjanic@rgf.bg.ac.rs

can be used to produce thermal and/or electrical energy (Templeton et al., 2014; Ilić et al., 2023). In this paper, completion of suspended and abandoned wells for the production of thermal and/or electrical energy is presented.

2 SUSPENDED WELLS

Well suspension is the process of temporarily shutting down a well, allowing it to be reactivated and used again in the future. Wells that have been suspended are temporarily out of use, but there may be a future need for their reactivation, for purposes such as the development of oil, gas, and condensate fields, the exploitation of geothermal, industrial, and mineral waters, underground oil and gas storage, or the disposal of industrial waste. Well suspension can be divided into two main types: long-term and short-term suspension.

Long-term suspension includes all procedures and measures applied when it is expected that the well will be out of service for more than a year. This type of suspension requires thorough preparations to ensure that the well remains in a stable condition during an extended period of inactivity, with minimal risk of damage. On the other hand, short-term suspension refers to situations when the well is out of use for up to one year. This approach involves less extensive protective measures but still ensures the functionality of the suspended well during the shorter timeframe (API recommended practice, 2009; Instruction on the procedure for the abandonment, conservation of wells, and the equipment of their wellheads and casings, 2010).

Well suspension is a complex process that consists of several key phases to ensure the long-term integrity of the well. Below are the basic phases of this process:

1. Preparatory work – Before starting suspension, a detailed inspection of the well is required. This inspection includes assessing the technical condition of the casing, checking the equipment at the wellhead, and analyzing the surrounding environment. Afterward, project documentation is created, which describes the suspension procedure in detail, considering the specific geological and ecological characteristics of the location. Additionally, all materials and equipment, such as cement, drilling fluids, and suspension chemicals, need to be secured to ensure the smooth execution of the process.

2. Well suspension process – The first phase in well suspension is the isolation of the production layers, achieved by placing cement plugs. The height and exact placement of these plugs are determined based on the geological conditions of the well. Afterward, the well is filled with a neutral, anti-corrosive fluid to protect it from corrosion and contamination. The wellhead must be securely sealed to prevent unauthorized access and the entry of surface water or other contaminants. Additional protective equipment, such as pressure control devices, can be installed at the wellhead to ensure long-term suspension.

3. Monitoring and maintenance during suspension – During the suspension period, the well must be continuously monitored. This includes regular inspections of the wellhead, the integrity of the casing, and the level of suspension fluid. All necessary maintenance work, including replenishment of suspension fluid and equipment repairs, must be performed in a timely manner. All activities and inspections are recorded in the well's technical documentation, allowing for the tracking of its condition throughout the suspension period.

4. De-suspension procedure – When the well needs to be reactivated, the de-suspension process is carried out according to a pre-established plan in the project documentation. This process involves removing the drilling fluid and drilling out the cement plugs. The wellhead equipment is either repaired or reinstalled, and the well undergoes necessary pressure testing before being put back into operation. A final inspection is conducted to ensure that the well is in good condition and ready for safe and efficient exploitation (Instruction on the procedure for the abandonment, conservation of wells, and the equipment of their wellheads and casings, 2010; API Recommended Practice, 2009).

3 ABANDONED WELLS

Well abandonment is the process of permanently closing a well that is no longer in use. This process involves placing cement plug inside the well to ensure stability and prevent further fluid intrusion. Following this, the free section of the production casing is cut to remove unnecessary parts. Another cement plug is then placed to further secure the well, located just below the wellhead. Once this is done, the blowout preventer is dismantled, removing all remaining equipment from the well, and a cover cap is installed at the wellhead. Finally, the land where the well was located is restored to its original state and repurposed for agricultural or other uses, which includes the restoration of vegetation and the adaptation of the land for future use (Soleša et al., 2002; Instruction on the procedure for the abandonment, conservation of wells, and the equipment of their wellheads and casings, 2010).

Wells that need to be abandoned can be divided into four main categories, depending on the reason for their closure:

1. Wells that have fulfilled their purpose: These wells have completed their planned tasks, whether related to exploration, production, or other technological activities. This includes wells that have reached the end of their productive life, wells used for experiments, and those that served as underground storage facilities.

2. Wells abandoned for geological reasons: This category includes wells that encountered unfavorable geological conditions, such as non-reservoir zones, or wells that could not reach the projected depth due to obstacles like collapses or other geological anomalies.

3. Wells abandoned for technical reasons: These wells are abandoned due to technical problems, such as equipment failures, corrosion, or natural disasters. Wells that suffered significant damage during operation or were affected by poor site conditions also fall into this category.

4. Wells abandoned for technological, ecological, or other reasons: This category includes wells abandoned due to non-compliance with environmental standards, inadequate equipment, or prolonged inactivity. It also includes wells located in restricted areas or unsuitable for further exploitation due to changed circumstances (Instruction on the procedure for the abandonment, conservation of wells, and the equipment of their wellheads and casings, 2010; API recommended practice, 2009).

4 WELL PREPARATION FOR THE PRODUCTION OF THERMAL AND ELECTRICAL ENERGY

4.1 Suspended wells

Suspended wells offer the advantage of being immediately ready for use when needed, making them an efficient solution for temporarily inactive wells (Templeton et al., 2014)

To use a well for thermal and electrical energy production, it is necessary to isolate the entire production interval to prevent the mixing of the working fluid with formation fluids (oil, gas, or formation water). This is achieved by cementing all perforations and/or installing a cement plug. If the perforations are located at the bottom of the well, a cement plug is installed. However, when the perforations are not located at the bottom of the well, and to maximize the thermal energy from the well's lower sections, the perforations are cemented (Forward-Looking Framework for Accelerating Households' Green Energy Transition, 2024–2026; Templeton et al., 2014, Ganić,2024).

Figure 1 shows a schematic representation of a well with (a) a cement plug and (b) cemented perforations. Tubing is installed in the well, which is used for circulating the working fluid. The heated fluid moves from the bottom of the well to the surface, and after being used and cooled, it is returned to the same well through the annular space for reheating. This continuous circulation ensures that the heated working fluid is consistently brought to the surface.

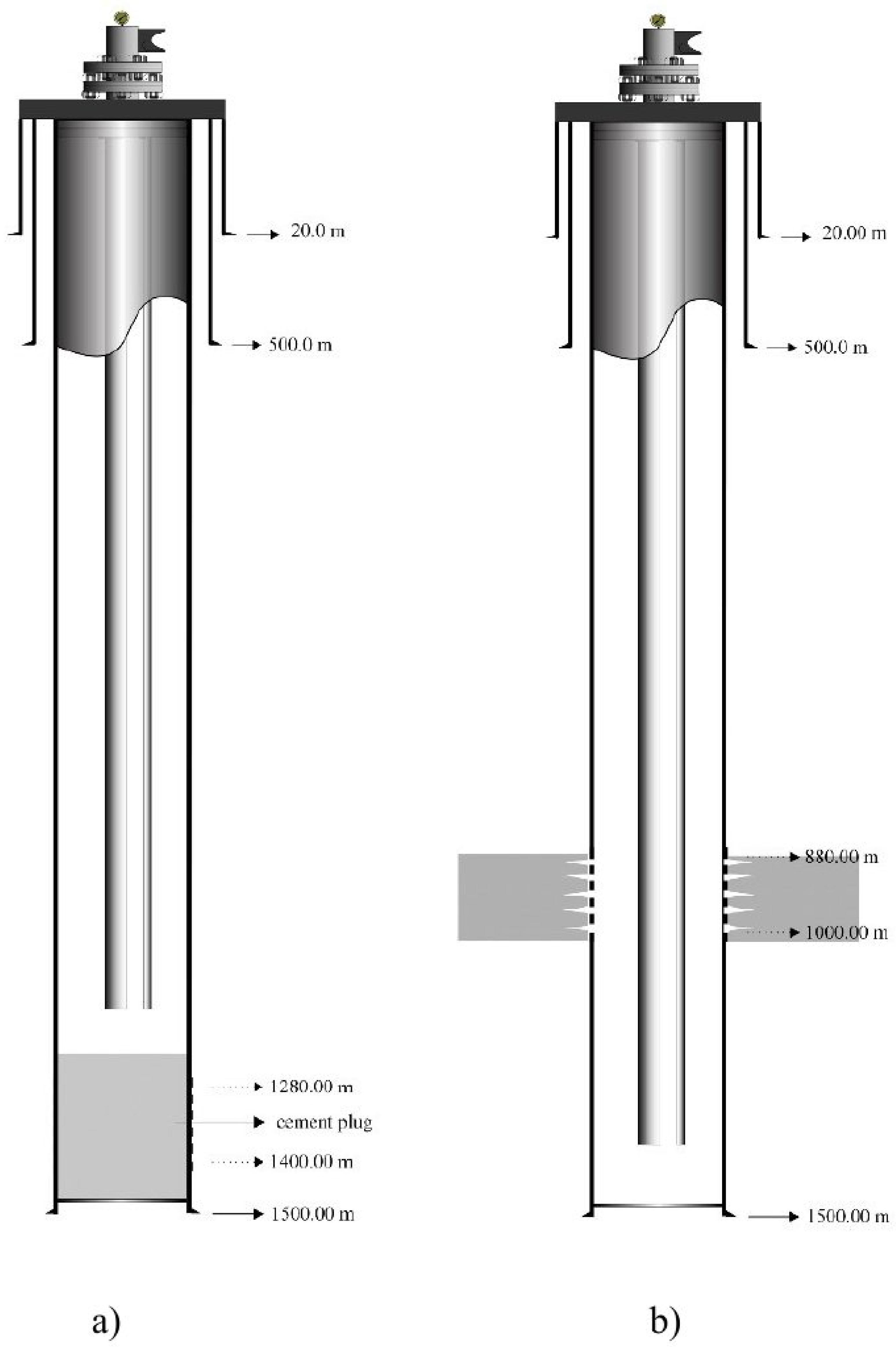

Figure 1 Schematic representation of a well with a) a cement plug and b) cemented perforations

4.2 Abandoned wells

On the other hand, abandoned wells (Figure 2) require higher costs for reuse, as the process involves additional tasks such as the removal of cement plugs, reopening the well, and reinstalling equipment. These additional steps make the use of abandoned wells more complex and expensive compared to suspended wells (Templeton et al., 2014). Figure 3 shows an abandoned well with a cover cap.

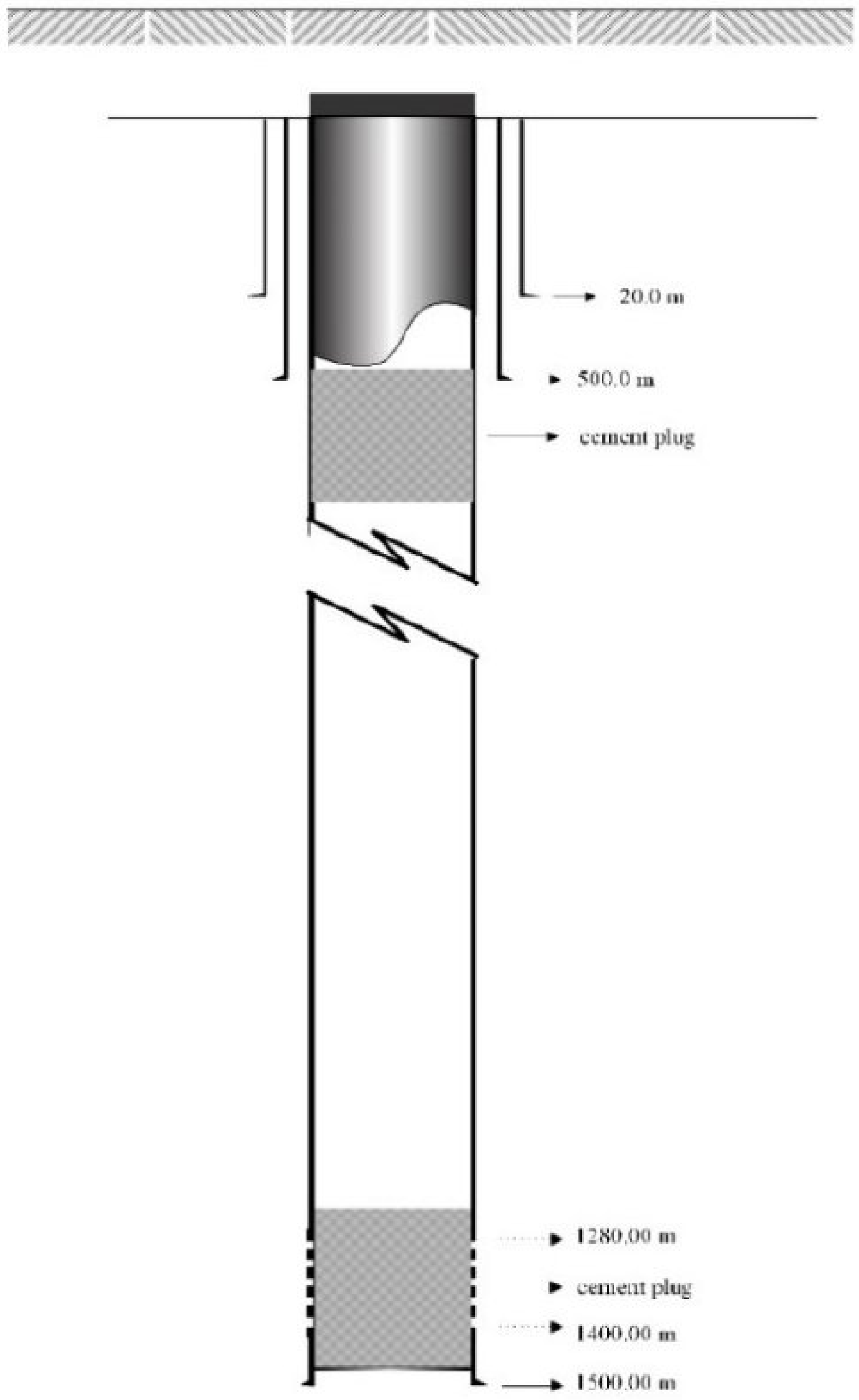

Figure 2 An abandoned well

Figure 3 An abandoned well with a cover cap

The most important procedure is the reinstallation of the production casing, which was cut during the abandonment process. This is achieved by welding a new section of the production casing. Figure 4 shows a detailed view of the welded production casing.

Figure 4 A detailed view of the welded production casing

Figure 5 schematically shows an abandoned well equipped for the production of thermal and electrical energy.

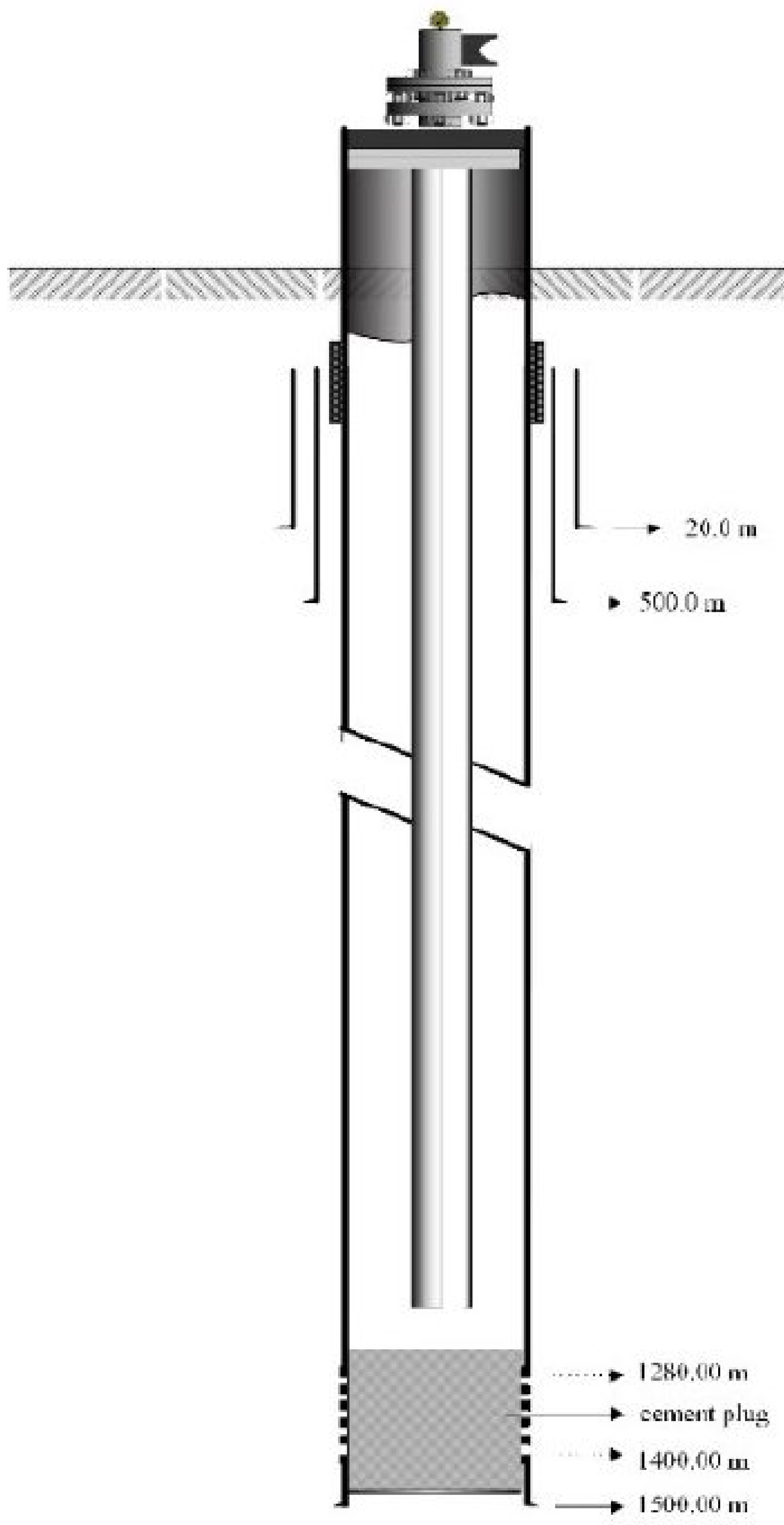

Figure 5 Schematic representation of an abandoned well equipped for the production of thermal and electrical energy

The surface equipment includes a blowout preventer, which is the same for both suspended and abandoned wells that have been re-equipped for production, as shown in Figure 6.

Figure 6 A blowout preventer

5 CONCLUSION

The reuse of suspended and abandoned wells for the production of thermal and electrical energy represents an efficient and sustainable solution. The use of these wells directly enables the valorization of an unused energy resource.

Suspended wells can be more easily repurposed at lower costs, while abandoned wells require additional work but still offer significant energy potential. This approach reduces dependence on fossil fuels and utilizes existing infrastructure, contributing to environmental sustainability.

Completion of suspended and abandoned wells for the production of thermal and/or electrical energy involves significantly lower costs compared to drilling new deep wells, which can reach up to 2 million dollars. Therefore, suspended and abandoned wells are not only an energy resource but also a significant economic asset. By utilizing this existing infrastructure, initial investments are reduced, increasing the economic viability of transitioning to renewable energy sources.

Suspended and abandoned wells are used for circulating the working fluid through the tubing to the surface, after which the utilized cooled fluid is returned to the same well through the annular space for reheating. Through this circulation, heated working fluid from the well is continuously brought to the surface.

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