Interreg CENTRAL EUROPE

Co-funded by the European Union

TRANSGEO

Feasibility study for the pilot region Lausitz (North German Basin)

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0. Executive Summary

This report assesses the feasibility of integrating geothermal energy into the Lausitz region of Germany, a region undergoing significant energy transition following the planned phase-out of coal. The Lausitz region presents a unique opportunity to leverage existing energy infrastructure and geological conditions for sustainable heating and cooling solutions.

Currently reliant on legacy coal-fired district heating networks, the region is actively seeking alternatives to meet heating demands while aligning with Germany's climate goals. This study identifies significant potential for Underground Thermal Energy Storage (UTES), particularly Aquifer Thermal Energy Storage (ATES), as a viable solution. The Lower and Middle Buntsandstein formations are highlighted as a promising reservoir, offering favourable geological conditions for UTES implementation.

While deep geothermal systems such as Borehole Heat Exchanger (BHE) and Borehole Thermal Energy Storage (BTES) are technically possible, they are likely not economically feasible due to the requirement for new drilling. Opportunities for BHE and BTES are limited to utilizing existing open boreholes where economic feasibility can be demonstrated, and a locally identified private entity possessing an active well may offer a potential pathway dependent on business foresight. Furthermore, the potential for reusing existing wells is constrained by specific requirements: the bottom-hole diameter must be larger than 7 inches, the well must be deep enough and intersect reservoir targets, and the well must be in open condition, not yet plugged and abandoned. Field surveys reveal challenges to well reuse, with many wells either not visible on the surface or in poor condition (as illustrated in **Figures 3.2(a) and (**b)). Other wells remain under private ownership (**Figure 3.3**), adding complexity to access.

Key Takeaways:

- **A Sustainable Future for Lausitz:** The region is moving beyond coal and seeking reliable, sustainable heating and cooling solutions.
- **Cost-Effective Energy Storage:** Underground Thermal Energy Storage (UTES), particularly using Aquifer Thermal Energy Storage (ATES), offers a promising and economically viable pathway.
- **Repurposing Existing Assets:** While challenging, utilizing existing wells can reduce costs and environmental impact – but requires careful assessment and collaboration.
- **Reducing Risk with Data:** Ongoing 2D seismic surveys are crucial for understanding the subsurface and minimizing investment risks.
- **Long-Term Potential**: Enhanced Geothermal Systems (EGS) represent a longer-term opportunity for sustainable energy production.
- **Building on What We Have:** Maximizing the use of existing infrastructure is key to a cost-effective and efficient energy transition.
- **Working Together for Success:** Collaborative partnerships between government, industry, research institutions, and local communities are essential for achieving a sustainable energy future in Lausitz.

This feasibility study demonstrates that geothermal energy, specifically through UTES, can play a significant role in the Lausitz region's energy transition, transforming a coal-dependent area into a model for sustainable heating and cooling. Successful implementation requires continued investment in subsurface data acquisition, detailed reservoir characterization, and strategic development of UTES systems connected to existing district heating networks. Crucially, this will require close collaboration between local government, municipalities, private entities, research institutions, and other key stakeholders to unlock the full potential of this resource. The findings support prioritizing UTES as a key component of the region's future energy landscape, while acknowledging the limitations and challenges associated with reusing existing well infrastructure.

The TRANSGEO project (https://www.interreg-central.eu/projects/transgeo/) is co-funded by the European Regional Development Fund through the Interreg Central Europe program. The overall objective of TRANSGEO is to investigate the potential to transform abandoned hydrocarbon wells into new sources of green geothermal energy. To reach this goal, the TRANSGEO team is providing new tools and knowledge to support communities and industries in the energy transition and to break down economic and technical barriers to well reuse. This deliverable report reflects the views of the authors.

1. Introduction

Germany’s coal phase-out policy (*Kohleausstieg*) stands as one of Europe’s most ambitious climate and energy transition commitments. Enshrined in the 2020 Coal Exit Act, it mandates the gradual shutdown of all coal-fired power plants by 2038, with the possibility of accelerating the timeline to 2035, depending on interim assessments. This policy is a cornerstone of Germany’s *Energy Transition*—the national strategy to transition toward a low-carbon energy system—and is closely aligned with the European Union’s broader climate objectives, including the *EU Green Deal* and the Fit for 55 packages targeting a 55% reduction in emissions by 2030.

Coal, particularly lignite (brown coal), has historically underpinned Germany’s electricity generation and regional economies, especially in areas such as Lusatia (Lausitz), the Rhineland, and Central Germany. In cities like Cottbus, coal mining and energy production have long been economic lifelines. However, rising carbon prices, increasing environmental awareness, and international climate obligations, such as the EU’s goal of achieving climate neutrality by 2050, are accelerating the shift toward renewable energy sources.

Despite facing political and logistical hurdles, including concerns over energy security, the policy has sparked innovative regional redevelopment projects. A prominent example is the conversion of the former Cottbus-Nord lignite open pit mine into the *Cottbuser Ostsee lake*, Germany’s largest artificial lake, signifying ecological restoration and a new post-coal identity as shown in **Figure 1.1**.

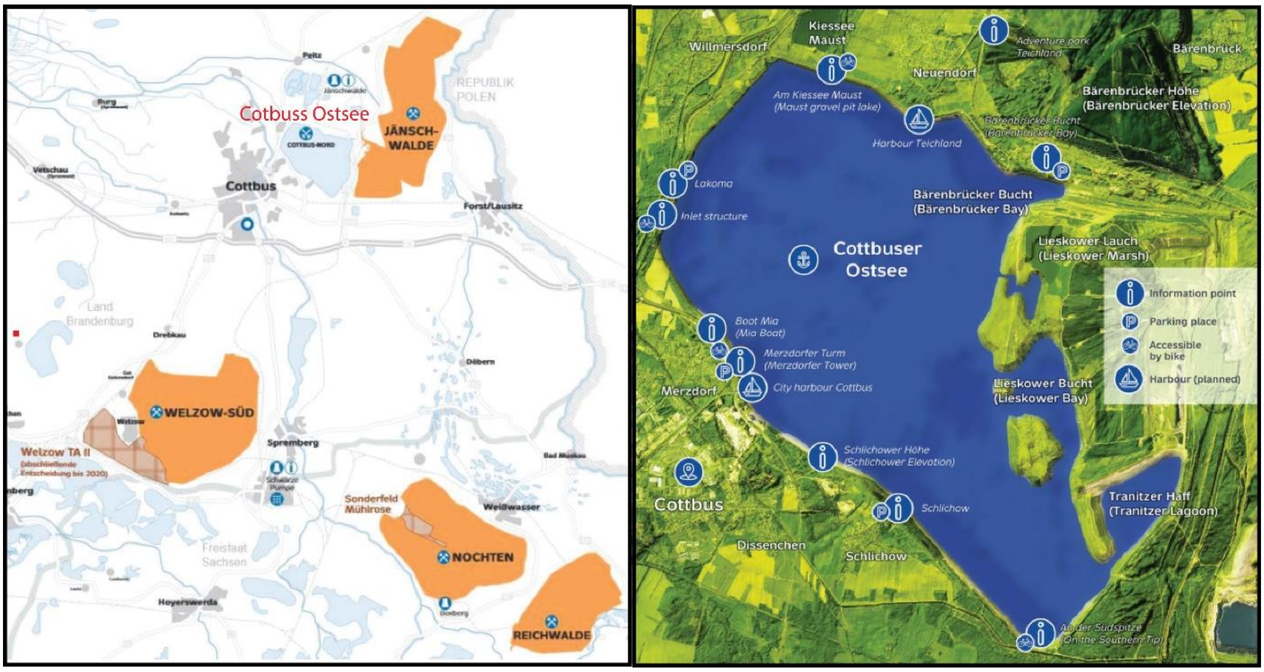


Figure 1.1: The areas in orange/brown show current and former lignite mines, including around Cottbus—one of Germany’s three major lignite regions. The right picture shows Cottbuser Ostsee development, the former Cottbus-Nord open-pit mine to become Germany’s largest artificial lake (LEAG, 2025). (Accessed July, 2025).

Additionally, extensive exploration for hydrocarbons and minerals such as copper and uranium has left the region with a legacy of nearly 15,000 drilled wells, most of which were related to lignite exploration. Today, the Lausitz region continues to play a central role in Germany's energy transformation with at least three coal power plants operated by LEAG: Jänschwalde, Schwarze Pumpe, and Boxberg (Saxony) with total installed capacities of 7175 MW (LEAG, 2025). The Jänschwalde power plant, operated by LEAG, with an installed capacity of 3,000 MW, has historically produced up to 11.9 billion kWh of electricity (LEAG, 2025). It is expected to be fully decommissioned by 2028, marking the final phase of lignite's contribution to Germany's climate targets, following earlier shutdowns and modernization efforts in the post-German reunification era.

As part of the EU-funded TRANSGEO project under the Interreg Central Europe Programme, Lausitz has been selected as a pilot region to explore post-coal energy pathways. A feasibility study is underway to assess the integration of geothermal energy for district heating and thermal energy storage. This initiative supports regional and European efforts to diversify renewable energy sources and advance the EU's climate neutrality goal. By repurposing geological knowledge and existing infrastructure, Lausitz is positioning itself as a model for sustainable transition—turning a fossil legacy into a renewable future.

2. Geographic location and analysis of spatial planning documentation

2.1 Location

The Lausitz is a region, which expands over the southern part of Brandenburg, the eastern part of Saxony and the southwestern part of Poland. It can be traditionally subdivided into an upper and lower part (Nieder- and Oberlausitz). The area of Lausitz within the State of Brandenburg is centered around the city of Cottbus, which is a city in eastern Germany as shown in **Figure 2.1**. With approximately 100,000 inhabitants, it is the second-largest city in Brandenburg after Potsdam and serves as a regional center for the Lausitz area.

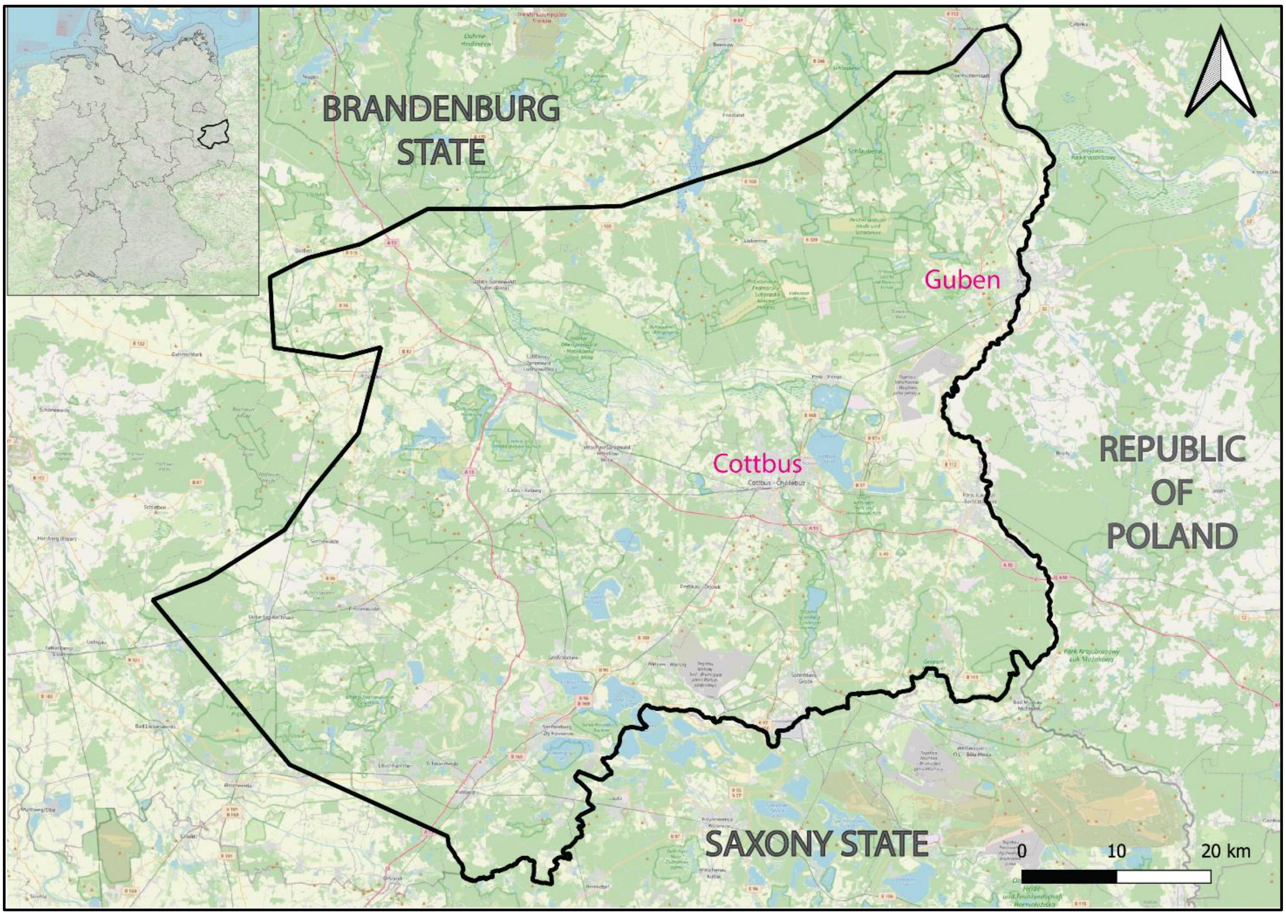


Figure 2.1: The Geographical location of the Lausitz region. Source: https://www.openstreetmap.de/karte/#. (Accessed September, 2025).

2.2 Transport connectivity

As shown in **Figure 2.2**, the city of Cottbus is located about 124 km from the centre of Berlin. The area can be reached by two modes of transport: the regional train or car. The closest airport for air travel is Berlin Brandenburg Airport, located about 108 km from the city of Cottbus. Another alternative airport is Dresden Airport, which is approximately 124 km away. The regional train from Berlin takes approximately 1 hour and 20 minutes to reach Cottbus main station, while the journey from Dresden takes around 1 hours and 40 minutes by train from Dresden-Neustadt. The city of Guben can be reached from Cottbus by car in approximately 1 hour, or by train in around 40 minutes.

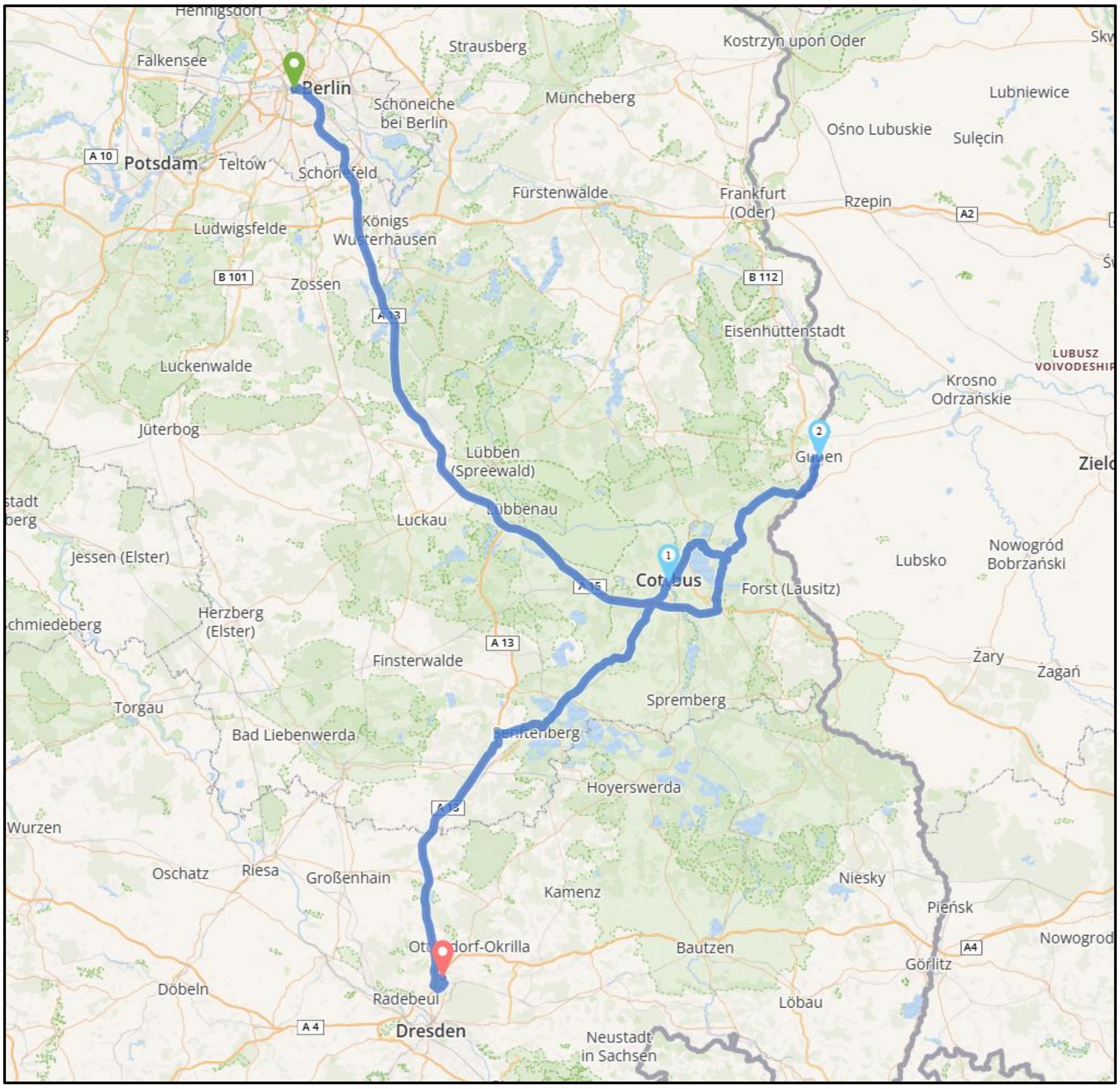


Figure 2.2: Transport connectivity to the pilot site. The figure shows the location of Cottbus-center relatively to the Berlin-Brandenburg and Dresden Airports. Source: https://www.openstreetmap.org/#map=6/49.81/7.89&layers=TGN. (Accessed September, 2025).

2.3 Demographic aspects

As shown in **Figure 2.3**, the Lausitz region is divided into two major municipalities: Cottbus city, which is equivalent to a county-level city, and Spree-Neiße, which is equivalent to a county. Cottbus, the center of the region, covers an area of 165.5 km^2 and had an estimated population of 95,123 in 2024, a 0.48% increase compared to 2022 (Citypopulation, 2025). This gives it a population density of 574/km^2. Meanwhile, Spree-Neiße covers an area of 1,657 km^2 and had an estimated population of 109,635 in 2024, a decrease of 0.51% compared to 2022 (Citypopulation, 2025). This gives it a population density of 66/km^2. Spree-Neiße district was formed in 1993 by merging the former districts of Cottbus-Land, Forst, Guben and Spremberg. Overall, the total population of both cities has increased since 2021. **Figure 2.4** summarizes the population composition by age and gender.

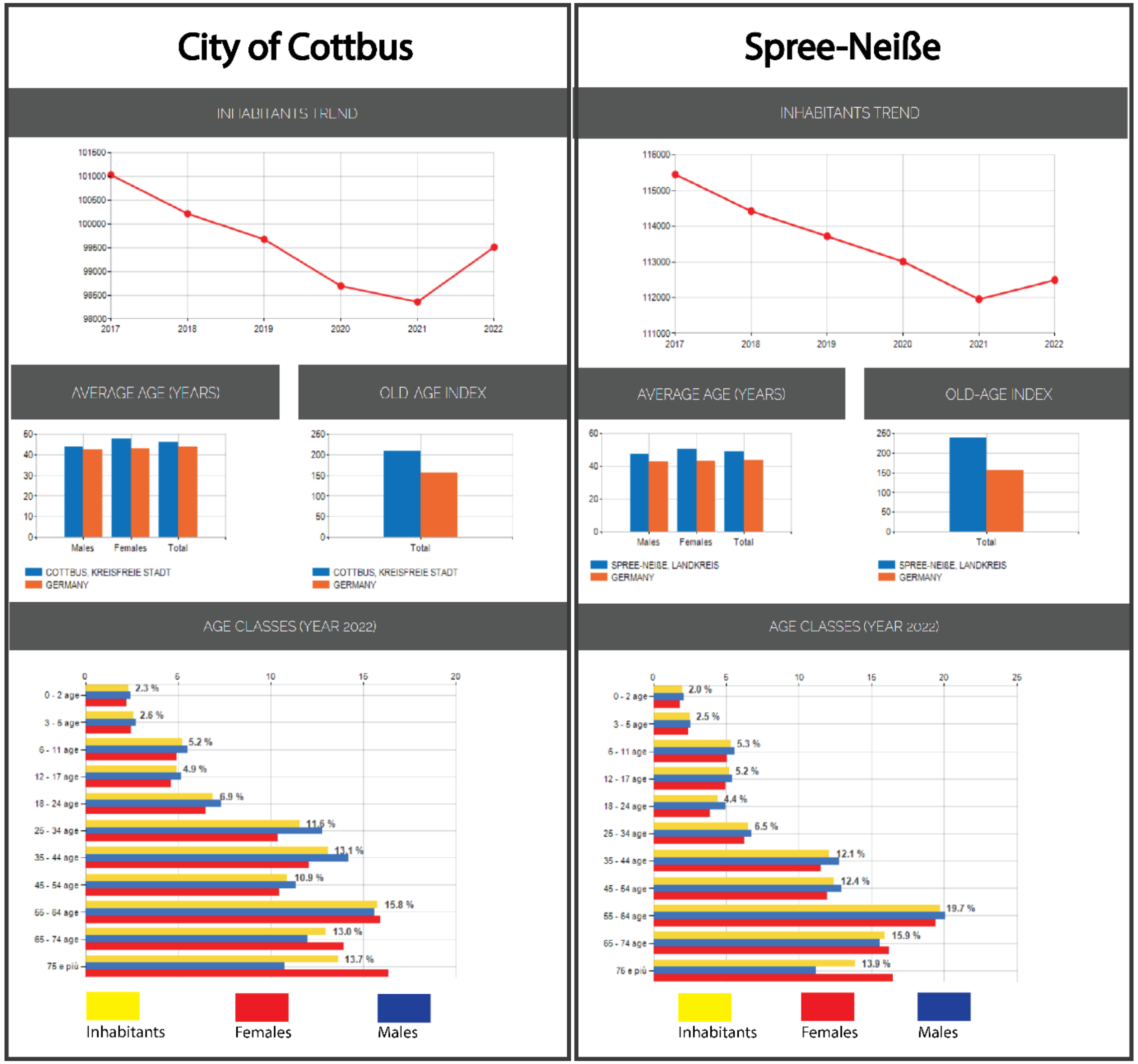


Figure 2.4: Demographic condition to 2018. Source: https://ugeo.urbistat.com. (Accessed July, 2025).

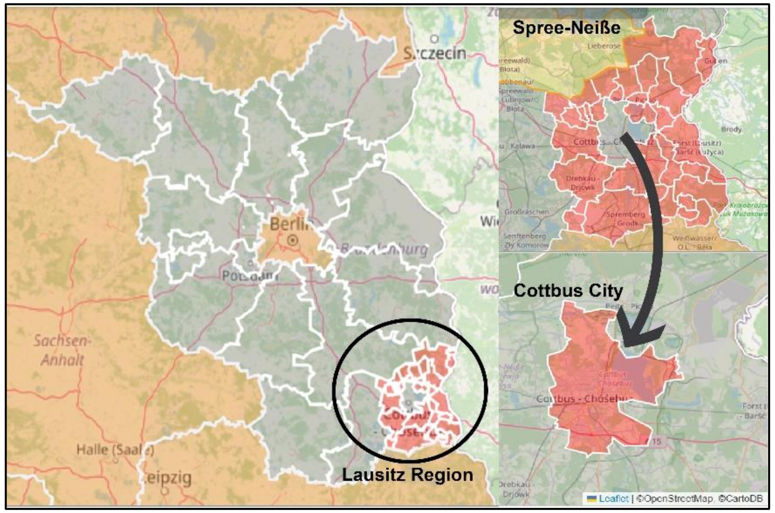


Figure 2 3: Map of municipalities in Lausitz region representing the major population areas of Cottbus city and Spree-Neiße. Source: https://ugeo.urbistat.com. (Accessed, July 2025).

2.4 Power grid

2.4.1 Power grid

As a former coal mining region, Lausitz hosts several major coal-fired power plants in eastern Germany, as listed in **Table 2.1**. The concentration of these power stations has contributed to Lausitz becoming one of the most developed areas in eastern Germany in terms of electrical grid infrastructure (LEAG, 2025). As illustrated in **Figure 2.5**, the region's major coal power plants are connected to the 310 kV high-voltage transmission lines (purple), while 110 kV transmission lines (yellow) link urban areas to the regional distribution network. The main renewable energy sources in the Lausitz region are solar and wind power. Floating solar panels with an installed capacity of 29 MW, along with onshore wind turbines, have been deployed in and around the Cottbus Ostsee area. Additional installations are primarily located in the northern part of the region—particularly around Lübbenau-Spreewald—as well as in the southwestern areas, west of Spremberg.

Power plant	Installed capacity	Electricity produced 2023	Schedule of decommissioning
Jänschwalde	3000 MW	11.9 billion kWh	2 × 500 MW (already shut-down) 2 × 500 MW (2025) 500 MW (2026) 500 MW (2028)
Schwarze Pumpe	1600 MW	8.9 billion kWh	Complete shut-down (2038)
Boxberg	2,575 MW	12.2 billion kWh	2 × 500 MW (2029) Complete shut-down (2038)

Table 2.1: Major coal power plants in Lausitz (www.leag.de). (Accessed, July 2025).

2.4.2 District heating

District heating plays a crucial role in the context of Germany's coal phase-out, particularly in regions like Lausitz where legacy infrastructure remains highly relevant. Many district heating systems still in use today were originally constructed during the era of the German Democratic Republic (GDR), when domestic lignite served as the primary energy source. This system not only enabled efficient use of local coal but also reduced dependency on imported fuels (Konstantin, 2018).

As coal-fired power plants are progressively decommissioned under the Kohleausstieg policy, these heating networks face a growing supply gap. Without intervention, the phase-out threatens to disrupt the heating supply to thousands of connected households and public buildings. It is therefore essential to develop sustainable, regionally adapted alternatives that can replace coal as a heat source—ideally while preserving and repurposing the existing district heating infrastructure.

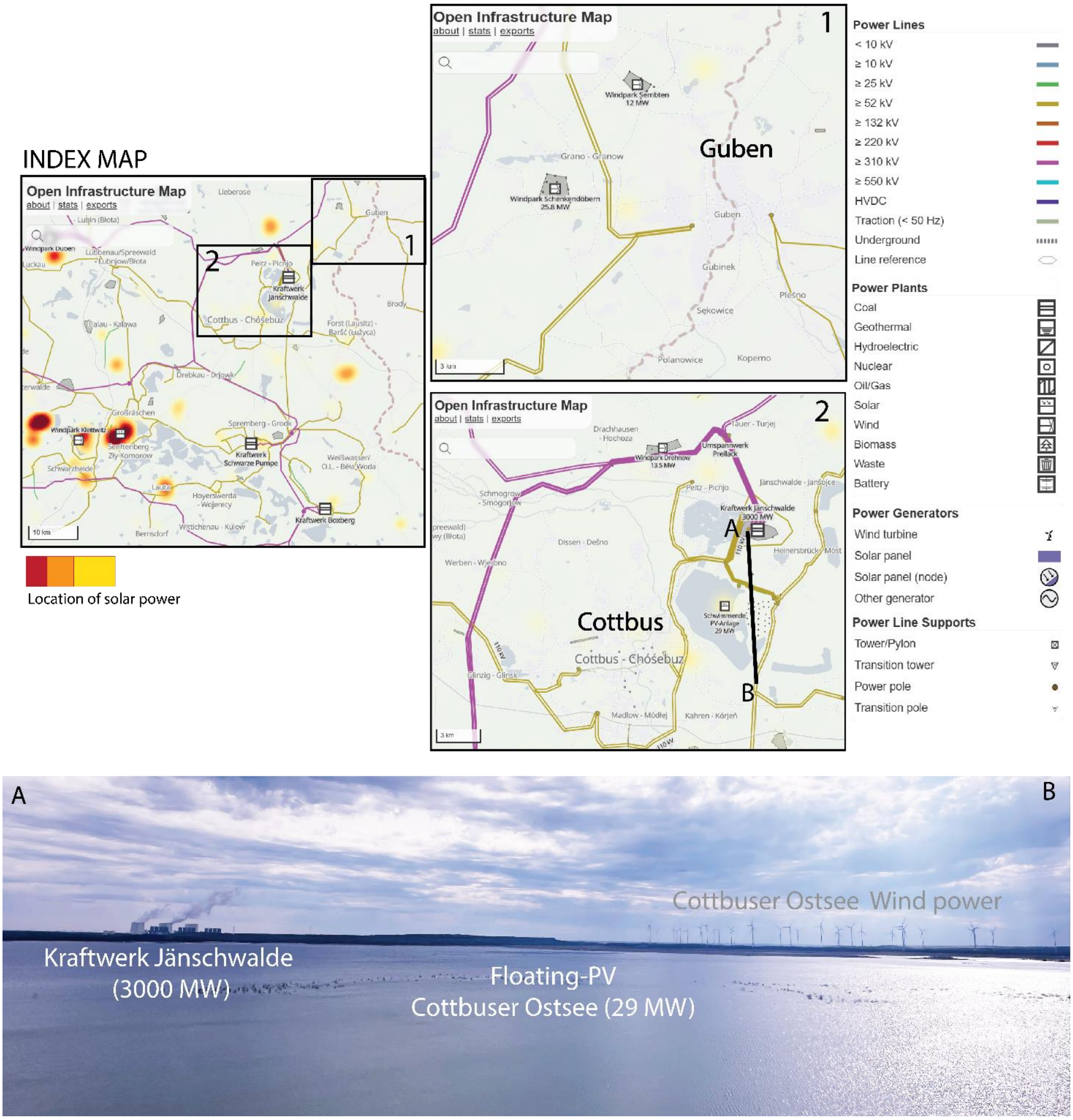


Figure 2.5: Power grids and power plants in Lausitz region. Source: https://www.openstreetmap.org/#map=6/49.81/7.89&layers=TGN. (Accessed September, 2025).

District heating networks in the Lausitz region are primarily operated by municipally owned companies, reflecting a strong tradition of local energy governance (**Figure 2.6**). In addition, several networks are managed by private corporations or cooperative entities, contributing to a diverse and resilient ownership landscape. The largest and most developed network is located in the city of Cottbus, where the district heating grid spans approximately 175 kilometers and supplies over 33,000 apartments. As of 2012, district heating covered 57% of all apartments in Cottbus (EVC, 2019), underscoring its essential role in urban energy provision.

Like Cottbus, many cities in the region operate integrated heating grids that serve the entire municipal area from a central network. To date, the Cottbus system has distributed an estimated 150 MWh of thermal energy, reflecting its significance in meeting residential heat demand. In some cases, however, district heating networks are organized into multiple local sub-grids to adapt to geographic or technical constraints. An example is found in the city of Guben, where a 19-kilometre heating grid is supplied by a single central thermal power station.
These existing systems represent a critical asset for the clean energy transition. By leveraging established infrastructure and ownership models—particularly at the municipal level—district heating networks offer a practical platform for integrating renewable heat sources such as geothermal energy, solar thermal systems, biomass, or industrial waste heat, in alignment with the goals of the EU's Renewable Energy Directive (RED III) and the EU Strategy for Energy System Integration.

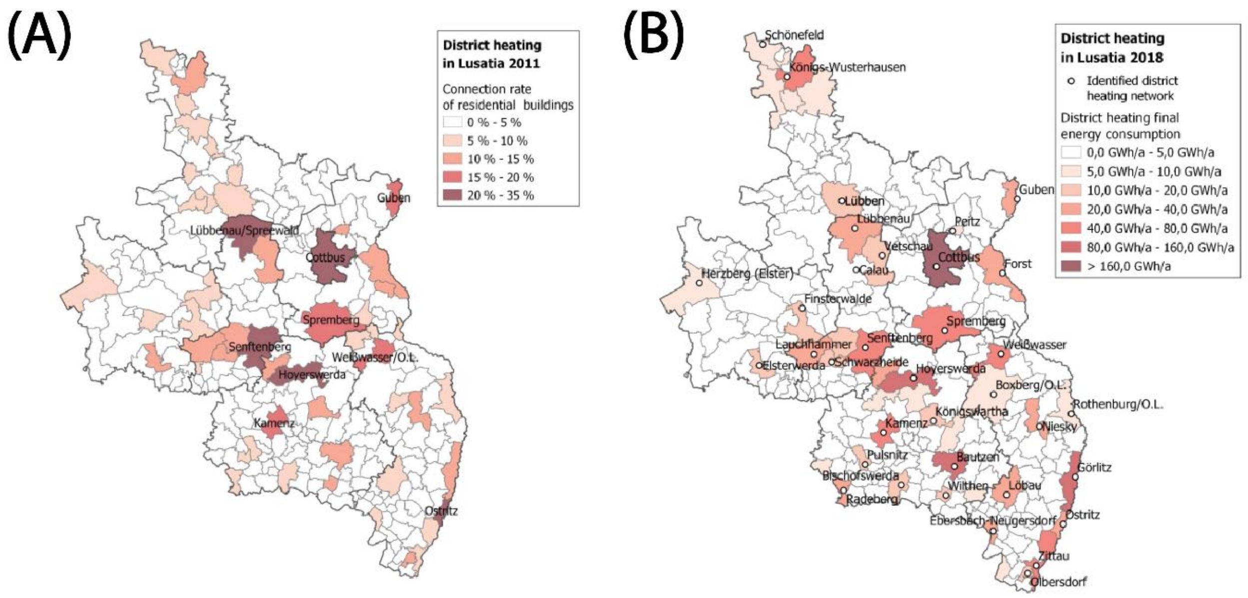


Figure 2.6: General overview of district heating in Lausitz. (A) Percentage of connection rate of residentia buildings in 2011; (B) Final energy consumption of each district in 2018 (Bhansen, 2020: data basis GeoBasis-DE . BKG 2019).

2.5 Compliance of interventions with current spatial planning documentation

2.5.1 Land use

The study area, depicted in **Figure 2.7**, encompasses approximately 1,800 square kilometers, including the city of Cottbus and the Spree-Neisse district. Based on the CORINE Land Cover (CLC) classification presented in **Table 2.2** (CORINE, 2018), the dominant land uses are agricultural areas (class 2) and nature parks (class 3), which together account for 80% of the total area. The remaining 20% is comprised of industrial and urban areas (10%, class 1), water bodies (9%, class 5), and wetlands (1%, class 4).

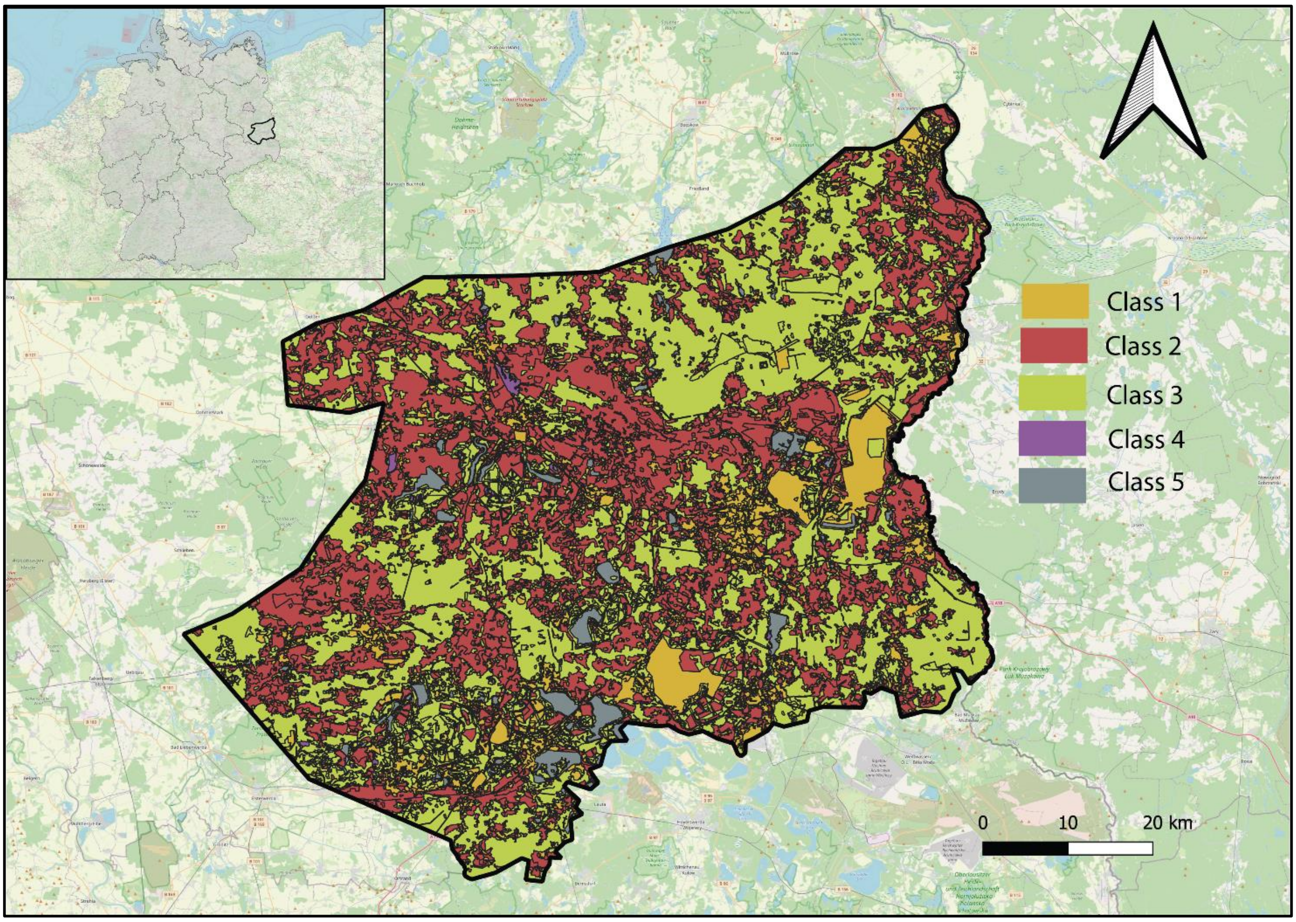


Figure 2.7: Overview of land use in Lausitz region (CORINE, 2018).

Class	Description of the class category
1	Continuous/ discontinuous urban fabric, industrial or commercial units and public facilities, road and rail networks and associated land, port areas, airports, mineral extraction sites, dump sites, construction sites, green urban areas, sport and leisure facilities.
2	Non-irrigated arable land, vineyards, pastures/meadows/ permanent grasslands under agricultural use, complex cultivation patterns, land principally occupied by agriculture with significant areas of natural vegetation.
3	Broad-leaved forest, coniferous forest, mixed forest, natural grassland, moors and heathland, transitional woodland/shrub, beaches, dunes and sand plains, bare rock, sparsely vegetated areas, burnt areas, glaciers and perpetual snow.
4	Inland marshes, peatbogs, coastal salts marshes, intertidal flats.
5	Water courses, water bodies, coastal lagoons, estuaries, sea and ocean.

Table 2.2 Description of the class category.

2.5.2 Spatial planning and water protection areas.

For centuries, the Lausitz region was characterized by vast forests, extensive bogs, and meandering rivers. However, the discovery and exploitation of vast brown coal deposits in the 20th century dramatically altered the landscape. Open-pit mining created a network of pits and disrupted drainage patterns, leading to significant environmental damage. Despite this, the Lausitz remains a biodiversity hotspot. As shown in **Figure 2.8**, the area features numerous water bodies, including lakes, and encompasses approximately 50% protected nature reserves such as the Biosphärenreservat Spreewald, Naturpark Dahme-Heidessen, Naturpark Niederlausitzer Heidelandschaft, and Naturpark Niederlausitzer Landrücken. The remaining natural and semi-natural habitats support a remarkable range of species. The wetlands are crucial breeding and foraging grounds for migratory birds, including iconic species like the white-tailed eagle (Haliaeetus albicilla) and black stork (Ciconia nigra). The region is also home to rare amphibians, such as the European tree frog (Hyla arborea) and the European fire-bellied toad (Bombina bombina), as well as a diverse array of dragonflies and butterflies. Unique heathlands and dry grasslands provide habitat for specialized plants and invertebrates.

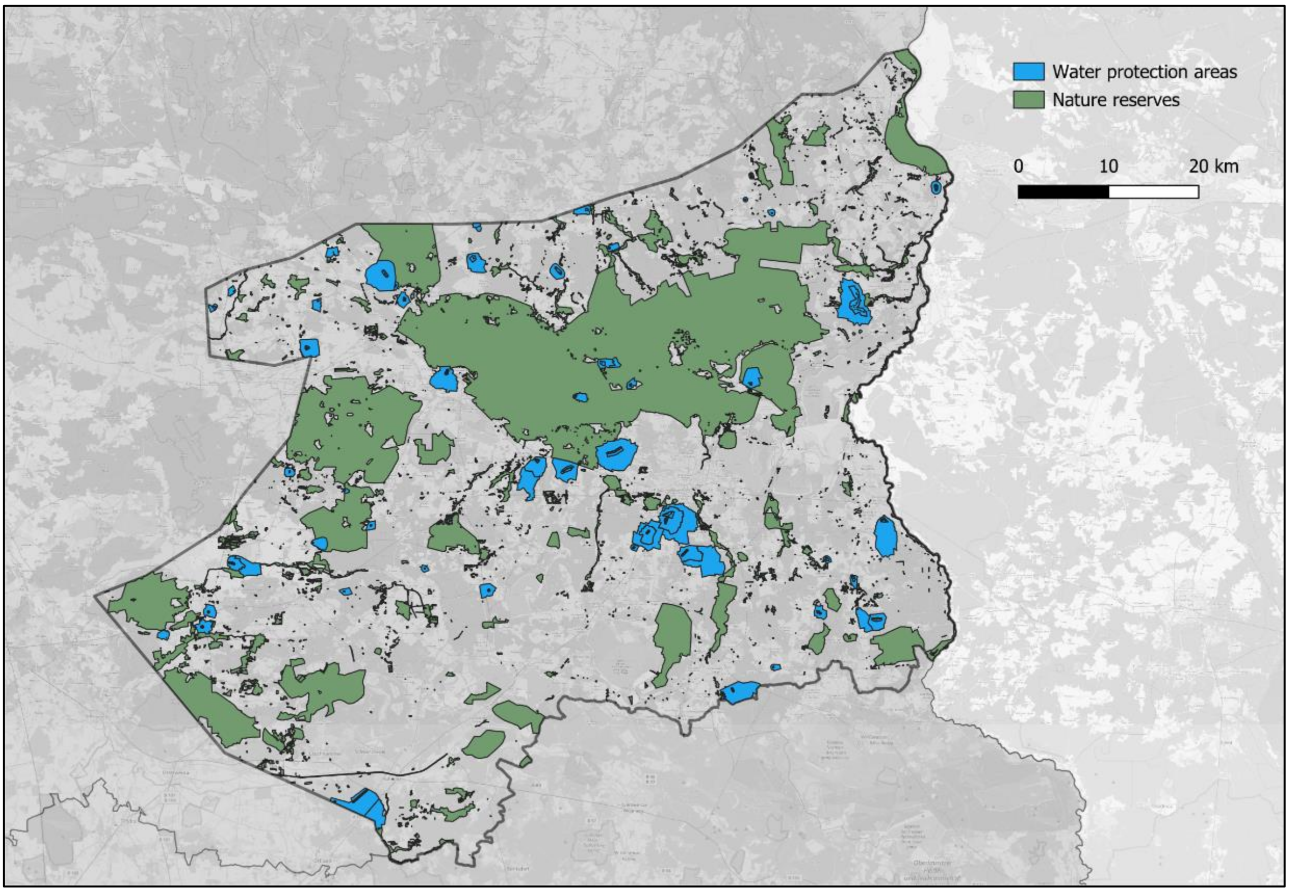


Figure 2.8: Spatial planning and water protection area (CORINE, 2018).

Today, the Lausitz is undergoing a profound transformation. With the planned phase-out of coal mining in Germany, large areas of former mining land are being remediated and re-naturalized. At the heart of this effort is the creation of the Nationalpark Lausitz, one of Germany's newest national parks, which aims to protect and restore the region's unique ecosystems. The post-mining landscape is being reshaped into a diverse mosaic of lakes, forests, and wetlands. This "lake district" will not only provide valuable habitat for wildlife but also offer opportunities for recreation and tourism. However, this transformation is complex. Challenges include managing water levels, preventing the spread of invasive species, and ensuring the long-term ecological sustainability of the newly created habitats. Balancing ecological restoration with the socio-economic needs of local communities is also crucial. The Lausitz aspires to be a model region for post-mining landscapes, demonstrating how to reconcile energy production with nature conservation and create a sustainable future for both people and wildlife. Similar, though less extensive, restoration efforts are also underway on the Polish side of Lusatia.

3. Research area

3.1 Description of research area

The Lausitz region has long been defined by its role in lignite mining and coal-based energy production. Over decades, it was also explored for other resources such as hydrocarbons, copper, and uranium, resulting in the drilling of nearly 15,000 wells—most of them related to lignite exploration (**Figure 3.1**). Today, Lausitz stands at a turning point. The region is actively embracing the energy transition, with early steps already taken to implement geothermal technology, especially through shallow Borehole Heat Exchanger (BHE) systems distributed in the Lausitz region.

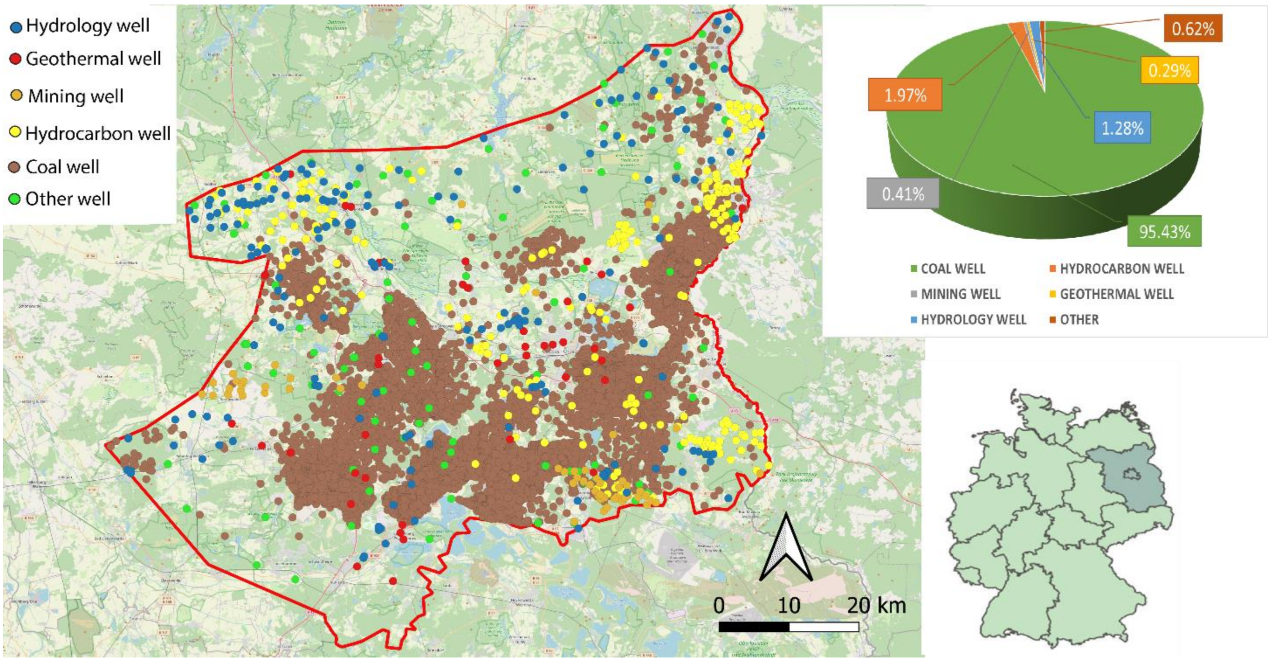


Figure 3.1: Overview of the legacy of drilling campaign from coal, hydrocarbon, and mineral explorations in the region. Source: Well database of LBGR Brandenburg.

These efforts are complemented by growing investments in solar and wind energy. Importantly, the wealth of geological and drilling data collected over the years now provides a strong foundation for identifying and unlocking deeper geothermal potential. This positions Lausitz not only as a historical energy hub but also as a front-runner in Germany's shift toward a more sustainable, diversified energy future. Details of the percentage of amount of the wells based on its initial purposes of drilling and/or current usages, and the range of the depths are described in **Table 3.1.**

Well Category	Total Number of Wells	Depth Range (m MD)
All wells	15341	100 - 2781
Coal Well	14639	100 - 703.9
Hydrocarbon Well	303	141.5 - 2781
Mining Well	63	245.8 - 1643.2
Geothermal Well	44	100 - 1350
Hydrology Well	197	100 - 367
Other	95	101 - 1138.4

Table 3.1 Total numbers of wells drilled in the Lausitz region, well types based on drilling purpose, and drilling depths. Source: well database of LBGR Brandenburg.

Regarding coal wells, most of those originally drilled for exploration purposes were subsequently lost during active lignite mining operations. Likewise, the majority of hydrocarbon and mining wells have been formally abandoned in compliance with Germany's mining regulations. Following decommissioning, these wells are required to be plugged and sealed to defined depths to prevent fluid migration, groundwater contamination, and structural instability, in accordance with the German Federal Mining Act (Bundesberggesetz, BBergG §55 and §63). Technical implementation of these procedures follows the guidelines outlined in DIN 4022, which governs borehole documentation, and VDI 4640-2, which specifies requirements for the construction, testing, and abandonment of boreholes for geothermal use. These regulatory and technical frameworks effectively render most legacy wells unsuitable for reuse, including for geothermal energy or monitoring applications. As a result, despite the historically high density of drilled wells in the region, their direct repurposing potential is significantly constrained.

A field survey was carried out in early 2024 to assess the condition of surface infrastructure under the responsibility of the State Office for Mining, Geology and Raw Materials. The primary objective was to compile a comprehensive inventory of existing wells in the Brandenburg and Lausitz regions, with a focus on identifying which—if any—remain structurally suitable for potential repurposing. This task is closely aligned with the goals of the TRANSGEO project, which aims to facilitate the transition from fossil-based to renewable heating systems by utilizing existing infrastructure.

However, as observed during the survey, many of the wells are still open and not legally plugged and abandoned, with surface conditions such as those illustrated in **Figures 3.2(a)** and **(b)**. But reusing the well is still not possible. All the other wells are not visible on the surface anymore. These findings highlight the challenges of reusing legacy infrastructure and underscore the need for targeted new development in areas with favorable geological and logistical conditions.

Figure 3.2: Rests of (A) old copper well and hydrocarbon well (B) in the Lausitz region. Source: LBGR field survey, 2025.

Figure 3.3, by contrast, presents an example of a well that recently abandoned and under the ownership of a private oil company, illustrating the continued presence of subsurface infrastructure that remains subject to commercial control. This example serves as a counterpart to the publicly managed infrastructure assessed in the field survey and reflects the varying degrees of accessibility and regulatory oversight across different well types in the region.

Figure 3.3: A recently abandoned hydrocarbon well, located in the north of the Lausitz region, remains under the ownership of a private sector entity. Source: LBGR field survey, 2025.

3.3 Well reuse criteria

The criteria for well reuse are classified based on the suitability of the technology: Deep Borehole Exchanger Systems (DBHEs), Hydrothermal Systems (HETs), Aquifer Thermal Energy Storage (ATES), Borehole Thermal Energy Storage (BTESs) and Enhanced Geothermal Systems (EGSs). In this feasibility study, the criteria are primarily dependent on the condition of the well itself. As set out in the well engineering workflow in the TRANSGEO Engineering Workflow document (Hofmann et al., 2025), the well reuse criteria are summarized as follows:

3.3.1 Deep Borehole Heat Exchangers (DBHE)

These systems are particularly valuable in areas where conventional geothermal reservoirs do not exist. Since only a pipe needs to be installed in an existing well, this technology is easy to implement. DBHEs are a typical well reuse technology, and new dedicated DBHE wells are usually not drilled for economic reasons. For the same economic reasons, abandoned wells cannot be used either, since redrilling the well and plugging it after DBHE use is too expensive. The well's condition must also be good, since the costs of logging/testing, well intervention and site preparation are too high. Furthermore, the heat customer must be nearby, since long heat transfer lines are too expensive.

3.3.2 Hydrothermal system (HE)

The existing well can be deepened into the geothermal reservoir. However, this reduces the well diameter, which can result in high frictional pressure losses, particularly when the new well section is long, the new well diameter is small, and the water production/injection rates are high. Shallower geothermal reservoirs can also be accessed from an existing well through perforations or a side-track. The challenge here is to achieve sufficient access to the reservoir through possibly multiple layers of casing and cement, and to ensure that the diameter of the side-track is not too restricted by the size of the main well. The best option is to reuse a hydrocarbon exploration well that found hot water instead of oil or gas because the least workover is needed, and the well has not been in use for many years.

3.3.3 Borehole Thermal Energy Storage (BTES)

BTES is the only heat storage option in deep wells where there is no permeable aquifer, and the techno-economic considerations are similar to those of DBHEs, since the amount of heat that can be stored in such a system is limited. When a nearby, low-cost heat source is available, storing heat in a DBHE with a co-axial design is the most viable BTES option for reusing deep wells.

3.3.4 Aquifer Thermal Energy Storage (ATES)

ATES wells serve as both injectors and producers. Since ATES systems are typically developed at shallow depths, the cost of drilling new wells is not as high as for deeper systems. The focus of reusing hydrocarbon wells is therefore on deploying deeper wells (1–2 km) for high-temperature ATES. ATES enables the storage of very large amounts of energy over long periods of time. However, there are only a few ATES systems in Central Europe, and none of them reuse old wells.

3.3.5 Enhanced Geothermal Systems (EGS)

While EGSs are currently the only option for large-scale heat production (tens of megawatts of thermal power) and power generation (about one-tenth of thermal power) in Central Europe, in areas where no permeable aquifer exists, these systems are still in the research and development phase. Several EGS demonstration projects have utilized existing hydrocarbon wells, including in Central Europe. Three reuse options exist: massive stimulations of an existing well (above, within, or below the hydrocarbon reservoir) to improve its injectivity or productivity, either by overcoming near-wellbore damage to access a permeable reservoir, or by improving the flow towards the well from an intermediately permeable reservoir. 2) Long horizontal wells with multiple parallel stimulation stages, depending on the stress field, seem to be the most suitable EGS development option. This would typically require a side-track from a relatively shallow section of an existing well to achieve the required horizontal section diameter of at least 7". 3) Induced seismicity poses a risk to EGS development, and induced seismic events are used to track fracture development, so it is vital to have a seismic monitoring well close to the EGS wells. Therefore, the most suitable reuse option for EGS developments is to use an existing well as a monitoring well.

"The most important requirements for well reuse are the bottom-hole diameter should be larger than 7 inches, the well are deep enough and intersecting the reservoir targets, and the well is in open conditions not yet plugged and abandoned."

3.3 Available data from the infrastructure at the pilot site

3.3.1 Coal well

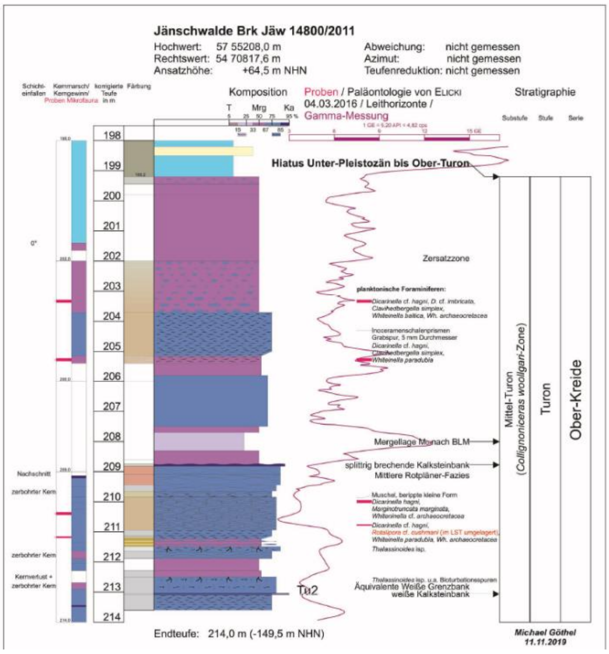


Figure 3.4: Lithology description of coal well (Elicki and Göthel, 2019).

The coal wells are relatively shallow, with an average depth of 100–300 meters. Many have been lost due to coal exploitation. Very few are still used for water monitoring. A lithological description is typically provided, as shown in the **Figure 3.4,** along with cuttings or core samples from the repository. Some wells include geophysical measurements, such as gamma ray, neutron, and caliper logs. However, the majority of coal wells have a bottom-hole diameter ranging from 2.76 to 7.8 inches, and several have been converted into groundwater wells to dewater the open-pit mining area. Based on their current condition, no existing coal wells are suitable for reuse.

3.3.2 Hydrology well

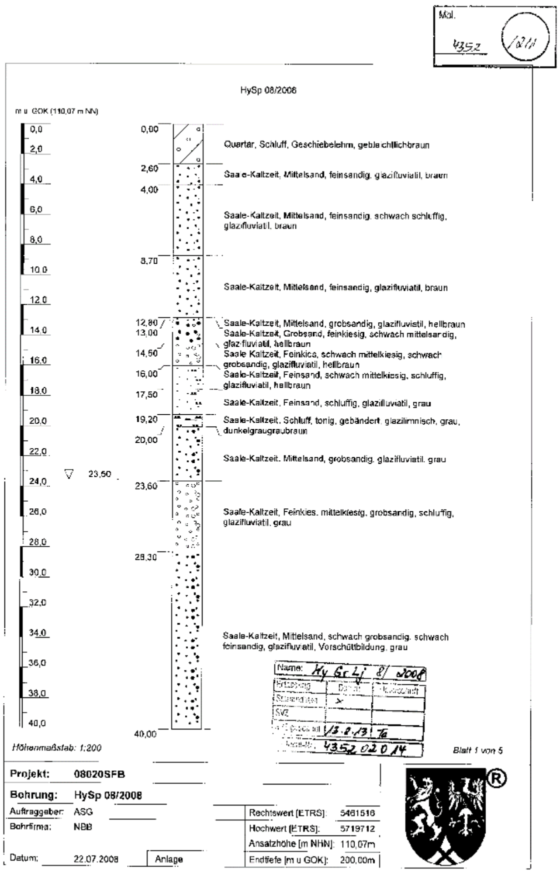
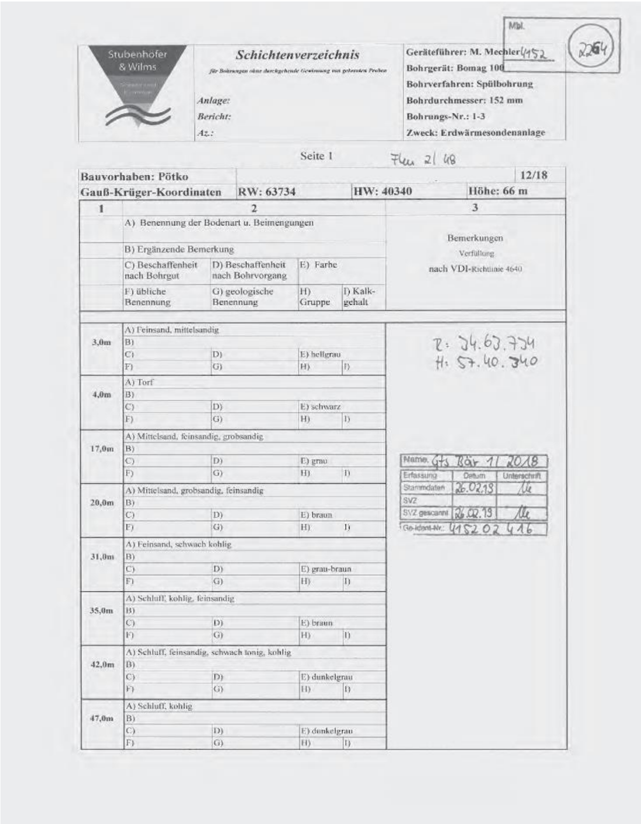


Figure 3.5: Lithology and wellbore schematic of hydrology well. Source: well database of LBGR Brandenburg.

Data from hydrology wells typically exhibit the following characteristics. These wells have an average depth ranging from 100 to 200 meters and are primarily used for groundwater monitoring, with limited data available from geophysical logging. Lithology descriptions, wellbore schematics, and specific completion details are typically provided as analog data, as shown in **Figure 3.5.** The bottom-hole diameter of these wells is around 3 to 4 inches. This diameter, combined with the average well depth, is insufficient for deepening for reuse, requiring a minimum 7-inch bottom-hole diameter.

3.3.3 Geothermal well



Stubenhöfer & Wilms

Schichtenverzeichnis

für Bohrungen ohne durchgehende Gewinnung von gekernten Proben

Anlage:
Bericht:
Az.:

Geräteführer: M. Mechler 4152
Bohrgerät: Bomag 100
Bohrverfahren: Spülbohrung
Bohrdurchmesser: 152 mm
Bohrungs-Nr.: 1-3
Zweck: Erdwärmesondenanlage

Mbl. 2264

Seite 1 Flur 2/ 48

Bauvorhaben: Pötko			12/18
Gauß-Krüger-Koordinaten	RW: 63734	HW: 40340	Höhe: 66 m

1	2	3
	A) Benennung der Bodenart u. Beimengungen; B) Ergänzende Bemerkung; C) Beschaffenheit nach Bohrgut; D) Beschaffenheit nach Bohrvorgang; E) Farbe; F) übliche Benennung; G) geologische Benennung; H) Gruppe; I) Kalkgehalt	Bemerkungen Verfüllung nach VDI-Richtlinie 4640
3,0m	A) Feinsand, mittelsandig; E) hellgrau	R: 34.63.734 H: 57.40.340
4,0m	A) Torf; E) schwarz	
17,0m	A) Mittelsand, feinsandig, grobsandig; E) grau	
20,0m	A) Mittelsand, grobsandig, feinsandig; E) braun	
31,0m	A) Feinsand, schwach kohlig; E) grau-braun	
35,0m	A) Schluff, kohlig, feinsandig; E) braun	
42,0m	A) Schluff, feinsandig, schwach tonig, kohlig; E) dunkelgrau	
47,0m	A) Schluff, kohlig; E) dunkelgrau	

Name: Gts Bär 1/ 2018

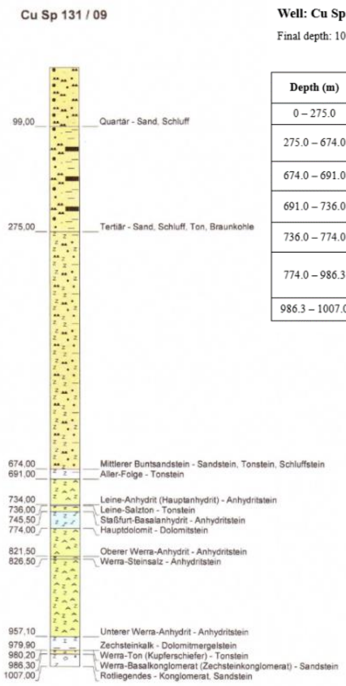
Erfassung	Datum	Unterschrift
Stammdaten	26.02.19	Me
SVZ		
SVZ gescannt	26.02.19	Me

Ge-ident-Nr.: 4152 02 416

Figure 3.6: Data for the geothermal well. Source: well database of LBGR Brandenburg.

The majority of geothermal wells in the Lausitz region were drilled for borehole heat exchangers (BHEs). This technology has been primarily implemented in Cottbus. As shown in **Figure 3.6**, these wells are relatively shallow, with an average depth of less than 150 meters. Because the wells were drilled in direct connection to buildings, repurposing them for other applications is strictly limited.

3.3.4 Mining well



Well: Cu Sp 131/09

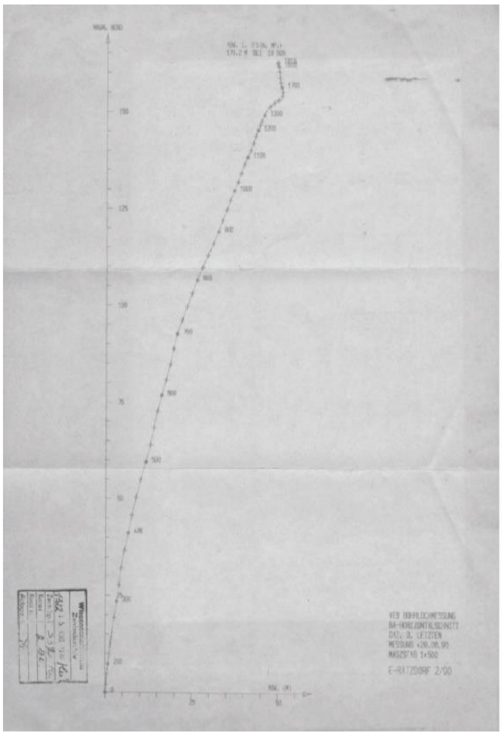
Final depth: 1007.0 m

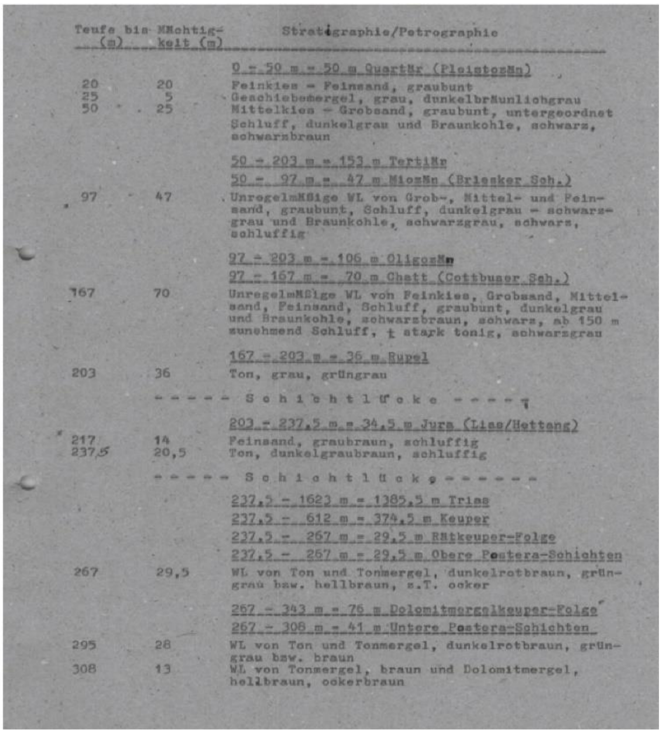
Depth (m)	Thickness (m)	Stratigraphic Position		Rock Type
0 – 275.0	275.0	Quaternary and Tertiary		Sand, gravel, lignite, clay
275.0 – 674.0	399.0	Trias	Mittl. Buntsandstein	Sandstone, claystone, siltstone
674.0 – 691.0	17.0	Perm (Zechstein)	Aller Serie	Claystone
691.0 – 736.0	45.0		Leine Serie	Anhydrite, claystone
736.0 – 774.0	38.0		Staßfurt Serie	Anhydrite, dolomite
774.0 – 986.3	212.3		Werra Serie	Anhydrite, dolomitic marlstone, claystone, sandstone
986.3 – 1007.0	20.7		Rotliegend	Conglomerate, sandstone

Figure 3.7: Data for mining well. Source: well database of LBGR Brandenburg.

Mining wells in the Lausitz region were drilled between 1958 and 2009. As shown in **Figure 3.7**, lithological descriptions and well depths are available for these wells. However, most have already been plugged and abandoned. While some wells have a diameter exceeding 7 inches, most were drilled between the 1950s and 1970s. An example of the remaining copper wells is shown in **Figure 3.2**. Consequently, these wells cannot be repurposed.

3.3.5 Hydrocarbon well





Teufe bis (m)	Mächtigkeit (m)	Stratigraphie/Petrographie
		0 - 50 m = 50 m Quartär (Pleistozän)
20	20	Feinkies - Feinsand, graubunt
25	5	Geschiebemergel, grau, dunkelbräunlichgrau
50	25	Mittelkies - Grobsand, graubunt, untergeordnet Schluff, dunkelgrau und Braunkohle, schwarz, schwarzbraun
		50 - 203 m = 153 m Tertiär
		50 - 97 m = 47 m Miozän (Briesker Sch.)
97	47	Unregelmäßige WL von Grob-, Mittel- und Feinsand, graubunt, Schluff, dunkelgrau - schwarzgrau und Braunkohle, schwarzgrau, schwarz, schluffig
		97 - 203 m = 106 m Oligozän
		97 - 167 m = 70 m Chatt (Cottbuser Sch.)
167	70	Unregelmäßige WL von Feinkies, Grobsand, Mittelsand, Feinsand, Schluff, graubunt, dunkelgrau und Braunkohle, schwarzbraun, schwarz, ab 150 m zunehmend Schluff, ± stark tonig, schwarzgrau
		167 - 203 m = 36 m Rupel
203	36	Ton, grau, grüngrau
		- - - - - S c h i c h t l ü c k e - - - - -
		203 - 237,5 m = 34,5 m Jura (Lias/Hettang)
217	14	Feinsand, graubraun, schluffig
237,5	20,5	Ton, dunkelgraubraun, schluffig
		- - - - - S c h i c h t l ü c k e - - - - -
		237,5 - 1623 m = 1385,5 m Trias
		237,5 - 612 m = 374,5 m Keuper
		237,5 - 267 m = 29,5 m Rätkeuper-Folge
		237,5 - 267 m = 29,5 m Obere Postera-Schichten
267	29,5	WL von Ton und Tonmergel, dunkelrotbraun, grüngrau bzw. hellbraun, z.T. ocker
		267 - 343 m = 76 m Dolomitmergelkeuper-Folge
		267 - 308 m = 41 m Untere Postera-Schichten
295	28	WL von Ton und Tonmergel, dunkelrotbraun, grüngrau bzw. braun
308	13	WL von Tonmergel, braun und Dolomitmergel, hellbraun, ockerbraun

Figure 3.8: Available data for hydrocarbon well. Source: well database of LBGR Brandenburg.

Hydrocarbon wells provide the highest quality data among all well types in the region. These wells offer the most extensive deep well data and a complete series of geophysical logs – including gamma ray, pressure, temperature, and resistivity – as well as lithology descriptions and well trajectories (shown in **Figure 3.8**). Due to the significant investment in hydrocarbon exploration – known for producing tradable fossil fuel energy – data quality is exceptionally detailed, including the availability of core or sidewall core data from deep wells (2000–4000 m) in particularly Brandenburg area. The avaiailability of data is also varied greatly fro each well. However, as previously explained, most active hydrocarbon wells remain under the ownership of oil companies, and their potential for repurposing for geothermal energy use is contingent upon company interest.

Figure 3.9: Example of core data available from the existing wells. The core was taken from Rotliegend Formation, which is the target reservoir for hydrocarbon exploration in the North German Basin.

3.4 Well reuse potential for ATES

As part of the TRANSGEO project feasibility study, initial efforts focused on repurposing existing infrastructure for Aquifer Thermal Energy Storage (ATES). ATES requires well locations near both the district heating network and a heat source – such as excess heat, waste heat, or district heating return flow – as well as wells with a minimum 7-inch diameter and demonstrated integrity.

A well selection tool (**Figure 3.10**, accessible at https://transgeo.smartcode.hu) was used to identify potentially suitable existing wells apart from the manual selection based on the well data based owned by LBGR. **Table 3.1** details the potential of well reuse for ATES technology (green color wells) within the Lausitz, Brandenburg area.

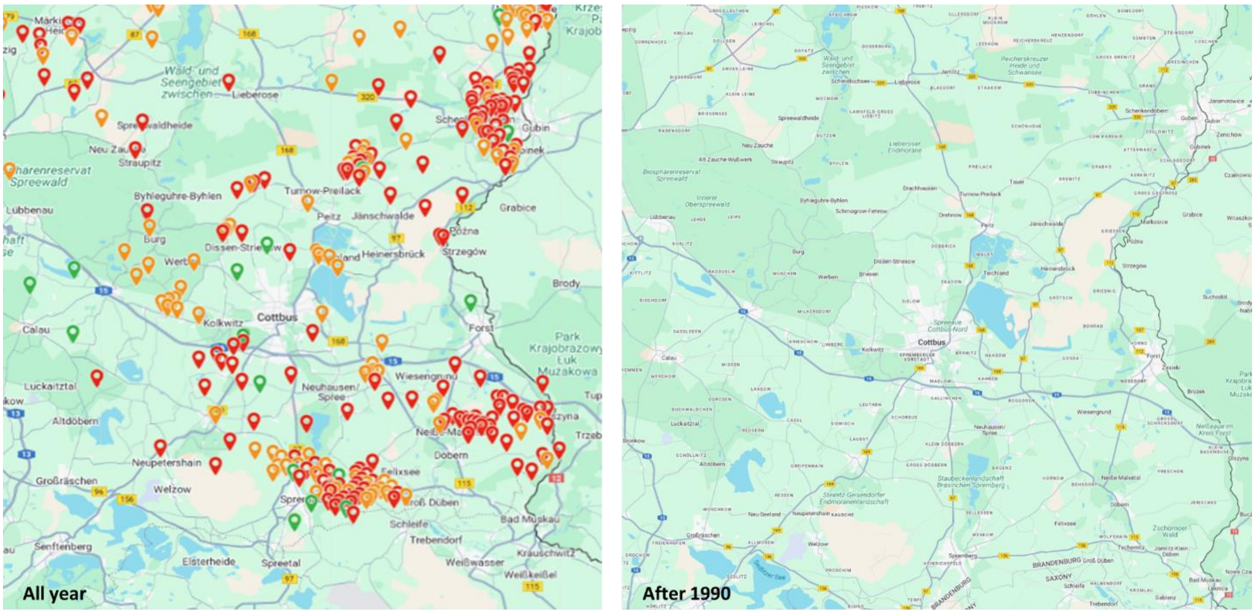


Figure 3.10: Advance existing well assessment for the ATES technology using well selection tool developed in TRANSGEO project. (https://transgeo.smartcode.hu).

Figure 3.10 shows that there are no suitable ATES wells specifically the wells that are younger than 30 years (from current dates). Most of the wells were drilled before 30 years as listed in **Table 3.1**. Based on the availability of data from the well selection tool and manual assessment, we concluded that the wells drilled between 1879 and 1986 are not viable for reuse. Therefore, developing ATES in this region necessitates drilling new wells, informed by existing subsurface data from these legacy wells.

Well Name	Drilling Year	Depth and type of the well
Brk Klba 1986/67	1986	851 m, coal exploration well
Kb Hä/17	1979	851 m, exploration well
Kb Hä/17	1979	851 m, exploration well
E Laz 103E/62	1962	780, hydrocarbon well
Kb Forst 1/61	1961	501 m, exploration well
Kb Werben 1/61	1961	494 m, exploration well
Kb Guben 1/61	1960	501 m, exploration well
Cu Sp 73/60	1960	957 m, Mining Well
Cu Sp 64E/59	1959	890 m, Mining Well
Brk Hä 3/1879	1879	851 m, coal exploration well

Tabel 3.1: ATES potential wells result from the well selection tool (https://transgeo.smartcode.hu).

4. Geology structure of potential location and available data for broader locations

4.1 Geology of the Brandenburg and Lausitz area

In order to gain a better understanding of the geology and structural characteristics of the Lausitz area and to identify the potential of geothermal application, this study utilised a three-dimensional model of the NEGB basin. This model was constructed using data collected during regional geological, structural and hydrocarbon explorations over a period of four decades (Scheck & Bayer, 1999; Jahnke et al., 2024). The updated model, as described by Jahnke et al. (2024), builds upon the TUNB 3D model (2014–2020), which incorporated around 24,500 km of seismic profiles (1,950 in total) acquired between 1960 and 1990, deep wells (831) and interpreted maps were used. Initially, seismic acquisition relied on analogue methods (1950s–1970s), targeting Mesozoic and Zechstein structures. However, digital surveys from 1971 onwards shifted the focus away from Mesozoic structures as primary hydrocarbon targets, instead refining them for potential underground storage and geothermal applications. Data density is highest over the Zechstein platform (southwest) and the Rotliegend formations (central basin), reflecting exploration priorities. Although exploration intensified with advancements in digital seismic methodology (Schretzenmayr, 1998), data coverage was limited by access restrictions (e.g., military areas, mining concessions and protected zones) and declined sharply after 1990.

The latest 3D model of Berlin and Brandenburg (Jahnke et al., 2024) as shown in **Figure 4.1**, particularly in the south and southeast of Brandenburg, incorporated refraction and shallow reflection seismic, which were used for lignite exploration, especially in the 1980s.

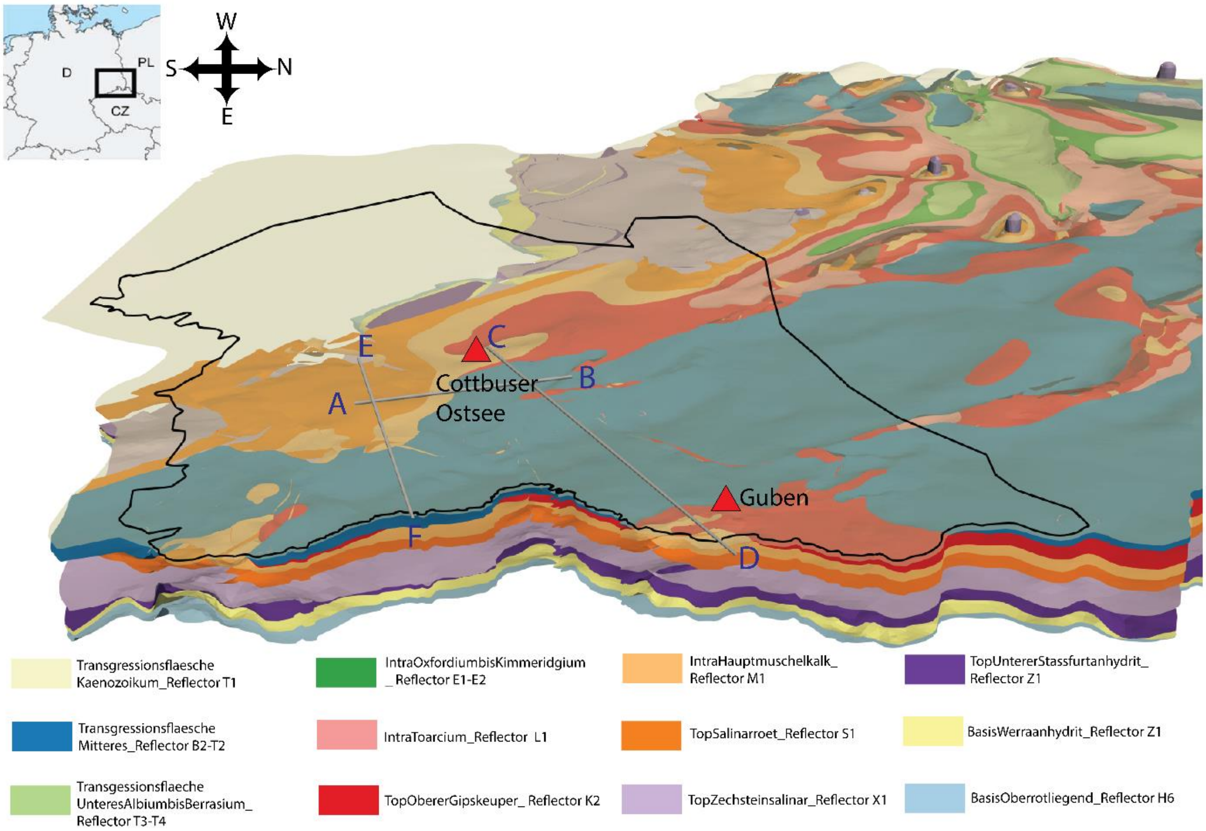


Figure 4.1 The 3D model of Berlin-Brandenburg area with a focus on Lausitz area. Source: https://gst.brandenburg.de/. (Accessed October, 2025).

These were not taken into account in the work carried out as part of the TUNB project, which involved the reinterpretation and reprocessing of seismic data. These discrepancies were harmonised and balanced locally in the three-dimensional Brandenburg model (by connecting to boreholes and closing rings with connections to the most recent profiles; in some cases, averaging and interpolation were also used). Up to 1990, seismic surveys in Brandenburg were carried out exclusively by a single contractor (the former VEB Geophysik Leipzig) and were systematically evaluated according to uniform methods and criteria. The results were continuously processed and harmonised in regional maps. The western Berlin area and the 3D surveys carried out in Brandenburg and Berlin after 1990 (e.g. Fürstenwalde in 1994, Berlin/Spandau in 2008 and Lübben in 2013) were not included in the 3D model either (Jahnke et al., 2024). In addition to drilling exploration and seismic data, there is comprehensive gravimetric and magnetic data for Brandenburg, though with varying resolutions. While these potential field methods have historically been used to identify deep structures and lignite deposits, they primarily address geological features outside the stratigraphic scope of the TUNB model (base Zechstein to base Rupel), and were therefore not included as primary data. Similarly, a large inventory of shallow boreholes (reaching Cenozoic depths) was extensively used in previous interpretations (Ahrens et al., 1968–1974; Gast et al., 2012), but was neither processed nor comprehensively integrated as primary data within the TUNB project and was only used sporadically. Existing maps and map series, largely based on data predating 1990/91, were also incorporated into model development.

4.2 Tectonic and geological setting of Lausitz region

The Berlin-Brandenburg states are located within the North German Basin, more specifically in its eastern and southeasternmost part (**Figure 4.2a** and **4.2b**). The Northeast German Basin (NEGB) is a sub-basin of the Southern Permian Basin (Ziegler, 1990). This location serves as a mediating point between the basin centre in Schleswig-Holstein, western Mecklenburg-Western Pomerania, and northern Lower Saxony, and the present-day southern edge of the basin (Jahnke et al., 2024). A pivotal element of this transition in the southeast is represented by the presence of profound fault zones (Central German Main Fault Zones), which act as a dividing line between the North German Basin and the Variscan consolidated bedrock of the European continental block north of the Alps (Jahnke et al., 2024).

In the preceding study (Scheck and Bayer, 1998), the NEGB Basin was located south of the Trans-European Suture Zone and north of the Elbe Fault System (**Figure 4.2a**). The study further delineated the NEGB Basin as being situated between the Northwest German Basin in the west, the Polish Trough in the east, and the North Danish Basin in the north (Scheck and Bayer, 1999). The NEGB is underlied on Variscan deformed crust in the south and Caledonian deformed crust in the north (Scheck and Bayer, 1999). The interest area around Cottbus and Guben is geologically located in the Niederlausitz Depression (**Figure 4.2b**). The Niederlausitz Depression is one of the geo-tectonic units forming the initial basement of present day Northeastern German Basin (Tietz and Büchner, 2015).

Following the Neoproterozoic Cadomian consolidation, which are mostly granodiorites and greywackes (Linnemann et al., 2010), the Lausitz Anticline Zone constituted a segment of the Avalonian-Cadomian orogen belt, situated at the northwestern margin of Proto-Gondwana (Göthel, 2001) during the time period spanning from 540 to 340 Ma. In the midst of this tectonic period, characterised by the Pre-Variscan uplift stage, the Lausitz area is comprised of three primary geo-tectonic units. The Lausitz Anticline zone is located in the southern part of the region, whilebasin and the Niederlausitz Depression are situated in the northern part of the Lausitz. The Görlitz Syncline Zone is delineated by the Intra Lausitz Fault, with the Main Lausitz Fault marking its northern border. This finding indicates the presence of autochthonous and allochthonous relicts from shallow marine shelf sediments at the northern margin of the Lausitz Anticline Zone and in the southern margin of the Variscan Görlitz Syncline Zone, including Lower Cambrian carbonates (Ludwigsdorf Members; Göthel 2001), Lower Ordovician siliciclastics (Dubrau Formation; Linnemann & Buschmann 1995) and the Lower Carboniferous limestone complex (Förstgen Formation; Göthel, 2001).

During the Post-Variscan uplift stage, which occurred between 340 and 250 million years ago (Ma), the Cadomian and Variscan units of the Lausitz Block underwent consolidation (Tietz and Büchner, 2015). This consolidation is attributed to the Variscan orogenesis, which is estimated to have occurred between 400 and 340 Ma. The most ancient post-Variscan, non-deformed sediments are recognised in the Doberlug-Kirchain Syncline, situated at the northwestern margin of the Lausitz Block. These sediments include the hard-coal-bearing Early Molasse beds from Upper Visean (Noldeke, 1976; 333–330 Ma, German Stratigraphic Commission, 2002). As described by Tietz and Büchner (2015), the Niederlausitz Depression and the Duben-Torgau Depression have been shown to accumulate the Variscan main Molasse debris of the largely eroded fold belt zone, which is connected with bimodal volcanism during the Lower Permian (Rotliegend). The thickness of the sediments in these basins surrounding the Lausitz Block range from 100 to 400 metres (Nowel, 1979).

The Mesozoic peneplain stage, which lasted from 250 to 100 million years ago, was marked by the break-up of Pangea and the subsequent extension. This was a significant geological period (Tietz and Büchner, 2015). Following this period, the basement of the Lausitz was levelled and covered by Triassic, Jurassic and Lower Cretaceous sediment sequences (Voigt, 2009; Hofmann et al., 2013) during the extension stage of the consolidated Variscan lithosphere (Stackebrandt & Franzke, 1989; Stackebrandt et al., 1994). This stage can only be inferred from the study of reworked detritus in younger sediment deposits in marginal basins, as the Mesozoic sediment cover has been completely eroded from the Lausitz Block (Voigt, 2009). Furthermore, the northwestern continuation of the Lausitz Block in the Prignitz Rampart suggests a more moderate tectonic setting. As posited by Voigt (2009), there has been an inversion and partial preservation of this Mesozoic sediment cover.

As described by Feldrappe at al., 2008, over a period of almost 200 million years, the North German Basin gradually became deeper. The main subsidence stage occurred from the end of the Permian period to the end of the Middle Buntsandstone period (Triassic period).

The subsequent differentiation of the basin continued into the early Upper Cretaceous period. This stage was characterized by the formation of smaller sub-basins and increased sediment thickness. This resulted in changing lithofacial conditions in the deposition area. There were several marine ingressions from the Arctic Ocean in the north and the Tethys in the south (see Ziegler, 1990; Walter, 1995; Kipping, 2004). Fluvial sediments were supplied from the Fennoscandian mainland in the north, the Bohemian Massif in the south-east, and the London-Brabant High in the south-west. From the Middle Jurassic to the Early Cretaceous, deposits also came from the Ringkøbing-Fyn High in the north (Katzung, 2004).

The investigation of potential geothermal formations and aquifers from the Mesozoic era is being examined due to depositional events involving large amounts of sediment in the basin. These counts on the formations such as the Upper Permian (Zechstein), Triassic, Jurassic and Lower Cretaceous periods. As a result of tectonic impulses during the Mesozoic era (Feldrappe at al., 2008), the Zechstein saline sequences were mobilised, significantly influencing the structural development of the North German Basin. Halokinesis created numerous saline structures, salt pillows, and salt domes in the subsurface with amplitudes of up to 8 km (Trusheim, 1957; Rüberg, 1976; Kossow et al., 2000; Krull, 2004, among others; see Fig. 1). Saline structures with predominantly NNE–SSW striking axes are found in the western part of the study area. These border Triassic–Jurassic trench systems with a similar orientation. In contrast, the eastern part of the North German Basin is dominated by saline structures with NW–SE striking axes. The numerous salt anticlines and diapirs significantly impact the geothermal conditions of the subsurface. Due to the high thermal conductivity of rock salt and anhydrite, temperatures at the top of saline structures and in their immediate vicinity are significantly higher than the normal geothermal gradient.

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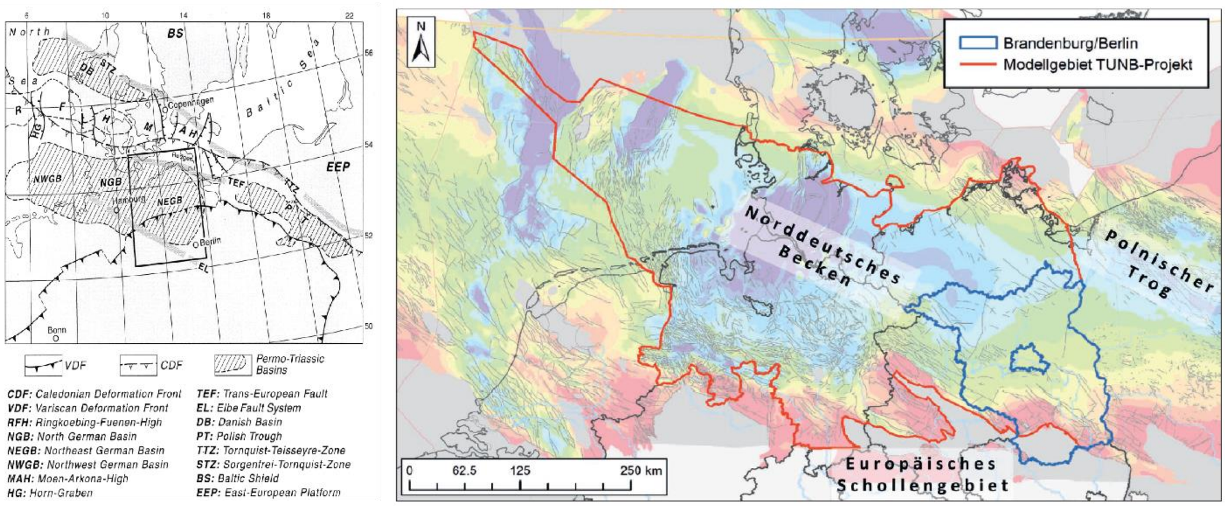
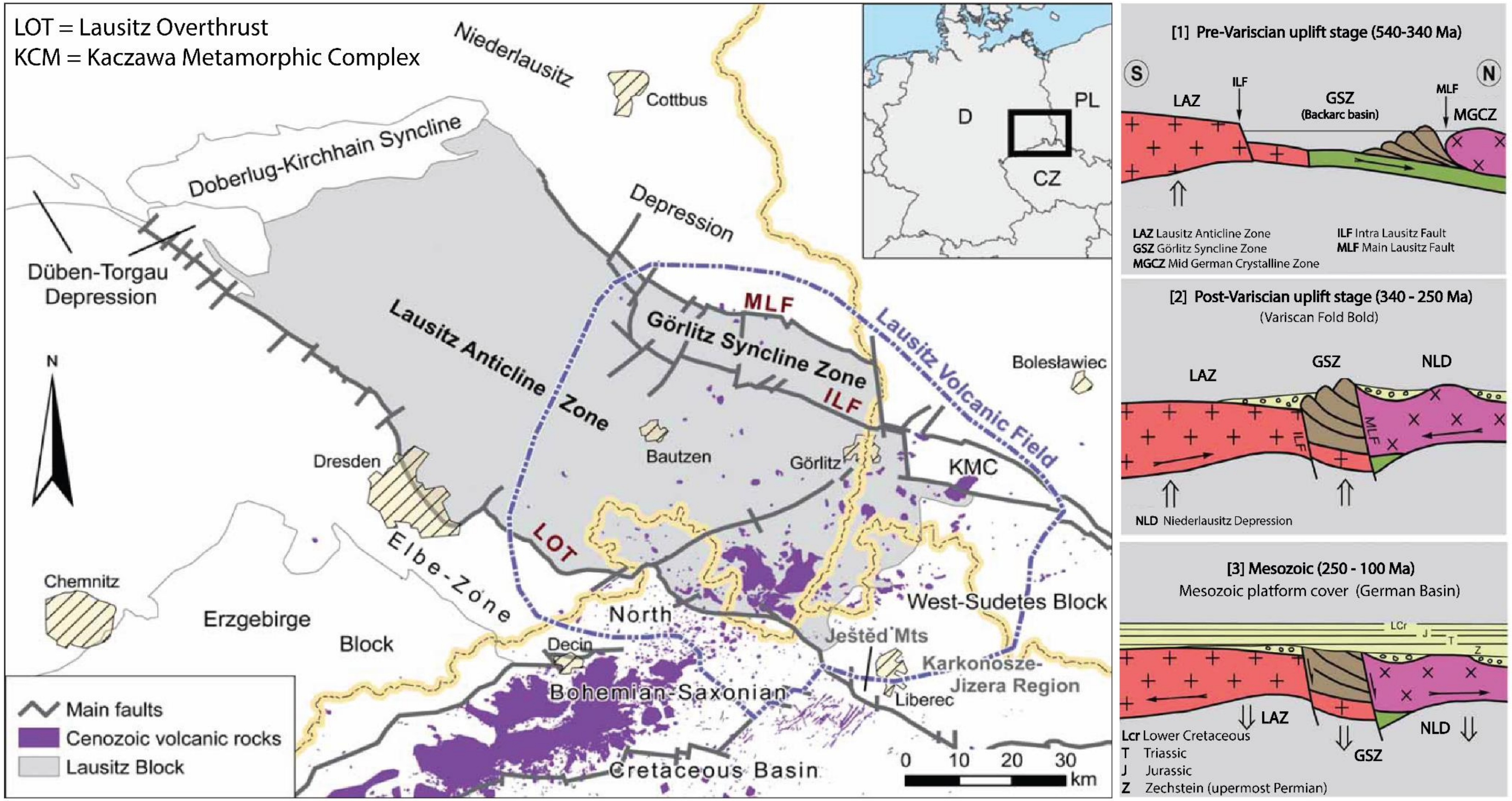


(Scheck and Bayer, 1999) (Jahnke et al., 2004)

Figure 4.2a: Tectonic setting of North German Basin and Brandenburg area (Scheck and Bayer, 1999; Jahnke et al., 2004).



Modified from Tietz and Bücher, 2015

Figure 4.2b Tectonic setting of Lausitz (Niederlauzits) area (Tietz and Bücher, 2015).

4.3 Characteristics of the aquifers in the research area

The characteristics of aquifers in the Berlin-Brandenburg region have been described in chronological order by Göthel (2006) and Feldrappe (2008). Notably, boreholes drilled in Brandenburg and Berlin between 1985 and 2001 for thermal water and geothermal energy exploration provided important new biostratigraphic data (Göthel, 2006).

Following the GDR state mapping drilling program (1953–1967), core samples—particularly from the Triassic and Jurassic—were extracted across Brandenburg. These samples are accessible at the Wünsdorf core repository of the Brandenburg State Office for Mining, Geology and Raw Materials, providing valuable insights into aquifer differentiation and a detailed stratigraphic classification of the Triassic and Jurassic periods.
A large number of Mesozoic core sections were utilized to study underground, unconfined storage facilities at the following sites (Göthel, 2006):

- Berlin-Spandau (1982–1991)
- Buchholz, near Treuenbrietzen (1964-1978)
- Dabendorf (1974)
- Flatow (1964–1965)
- Kabelitz (1960)
- Ketzin (1960–1975)
- Lehnin (1960)
- Mittenwalde (1974–1976)
- Potsdam (1961–1963)
- Wredenhagen (1979)
- Wesenberg (1973–1979)
- Wülpen (1960)

Caverns were constructed prior to 1998 for gas storage facilities, with brine being injected via boreholes. These mainly targeted the storage capacity of the aquifers in the anticline structure.

The chronology of geothermal-related aquifer delineation was further detailed by Feldrappe (2008), who focused on determining the base of the Mesozoic formation in relation to potential aquifers. Depth contour maps of aquifers at scales of 1:200,000 and 1:100,000 were created by Bruckner et al. (1990), Diener et al. (1988–1992), and Wormbs et al. (1988, 1989), using regional reflection seismic maps (Reinhardt et al., 1986–1989; Reinhardt, 1993) and drilling results.

Reflection horizons S1 (Top of anhydrites in the Salinarröt), S2 (base of the Salinarröt), and X1 (top of the Zechstein; see **Figure 4.3a**) were used to determine the base of the Buntsandstein (**Figure 4.3b**). The isobaths largely represent the base of the Detfurth Sandstone, as the Volpriehausen Sandstone is generally thin and highly cemented, limiting its reservoir significance. The maps mainly cover the southwestern and northeastern study areas, while the central North German Basin—dominated by pelitic facies—was excluded due to the thin sandstones and their low geothermal relevance. This gap was addressed by the GeotIS research project (Brandes & Obst, 2008).

The Schilfsandstein base and Lias base (**Figures 4.4a** and **4.4b**) were generated using reflection horizons K2 and T7 (upper Gipskeuper surface and Steinmergelkeuper transgression, respectively). The Aalen base depth contour map (**Figure 4.5b**) is based on the L1 reflector (display on Toarc), typically about 50 m below the top of Lias. The Lower Cretaceous base (**Figure 4.5a**) was constructed using T3 (Hauterivian transgression) and T4 (Wealden-Valanginian transgression) horizons. The digitized depth contour maps were then checked, supplemented, or modified using a drilling database containing aquifer-related layer data from more than 1,600 boreholes in northeastern Germany (Feldrappe, 2008).

Triassic and Jurassic stratigraphic systems follow the International Stratigraphic Commission scale (Gradstein et al., 2004; OGG & International Commission on Stratigraphy, 2006). Depositional environments and sequence stratigraphy can be interpreted only through detailed lithological documentation via core sections, complemented by geophysical borehole surveys and fossil content (Hardenbol et al., 1998; cited in OGG et al., 2006). According to Göthel (2006), economically significant aquifers in the Suprasalinar region occur in porous formations, including:

- Middle Buntsandstein (Volpriehausen and Detfurth formations)
- Upper Keuper (Contorta sandstone)
- Lias (Psilonoten, Lotharing, Hettang, and Domer sandstones)
- Dogger (Aalen sandstone)
- Lower Cretaceous (Neocom sandstones)
- Paleogene

This classification was based on detailed biostratigraphic analysis in wells Gt Nn 2/87 and Kb Su 1/63. Potential future economic significance may exist for permeable Lower Muschelkalk aquifers. In contrast, Upper Muschelkalk karst aquifers in the Upper Rhine Graben and Malm (southern Germany) are economically important but are lithologically different and thus not significant in Brandenburg.

Feldrappe (2008) identified the most significant geothermal storage horizons as:

- Middle Buntsandstein sandstones
- Schilfsandstein (Stuttgart Formation / Middle Keuper)
- Rhaetian/Lias aquifer complex (Upper Keuper to Lower Jurassic)
- Aalenian sandstone (Middle Jurassic)
- Lower Cretaceous sandstones (Wealden, Valanginian, Hauterivian)

Minor geothermal aquifers include the Hauptlettenkohle sandstone (Lower Keuper), Toarcian sandstones (Lower Jurassic), Bathonian and Bajocian sandstones (Middle Jurassic), Upper Cretaceous sandstones, and coral oolite (Upper Jurassic), and Pelitröt sandstone of upper Buntsandstein.

4.3.1 Middle Buntsandstone

According to Göthel (2006), and based on biostratigraphic correlations of marine conodont zones and epicontinental terrestrial conchostracan zones, as well as magnetostratigraphic data, the Triassic in Brandenburg begins with the Calvörde Formation, marked by the last appearance datum (LAD) of Falsisca posterra. This level corresponds to the Graubank area or the Rogenstein (Szurlies et al., 2003; Kozur & Bachmann, 2005). The siliciclastic facies of the Upper Zechstein deposits define the Zechstein saline boundary in the hanging wall, so that the Friesland and Fulda formations transition lithologically into the Buntsandstone in Brandenburg. The Rogenstein layers enable correlation of the Lower Buntsandstone, whereas the Bernburg Formation is delimited at the base of the Rogenstein or the Hauptoolith interval 1 (Szurlies et al., 2003). In the Burg Gt BuC 1/98 thermal water borehole west of Cottbus, the sandstones in the upper part of the Bernburg Formation are interpreted as an upper coarse sequence, which grades upward into the Middle Buntsandstone. In some cases, the base of these formations represents a hiatus (Göthel, 2006).

The Middle Buntsandstone in the Central German Basin begins with the Quickborn Sandstone (Lepper & Röhling, 1998). Feldrappe et al. (2007) subdivided the Middle Buntsandstone into the Volpriehausen, Detfurth, Hardegsen, and Solling formations (Feldrappe et al., 2008), a succession widespread across the North German Basin.

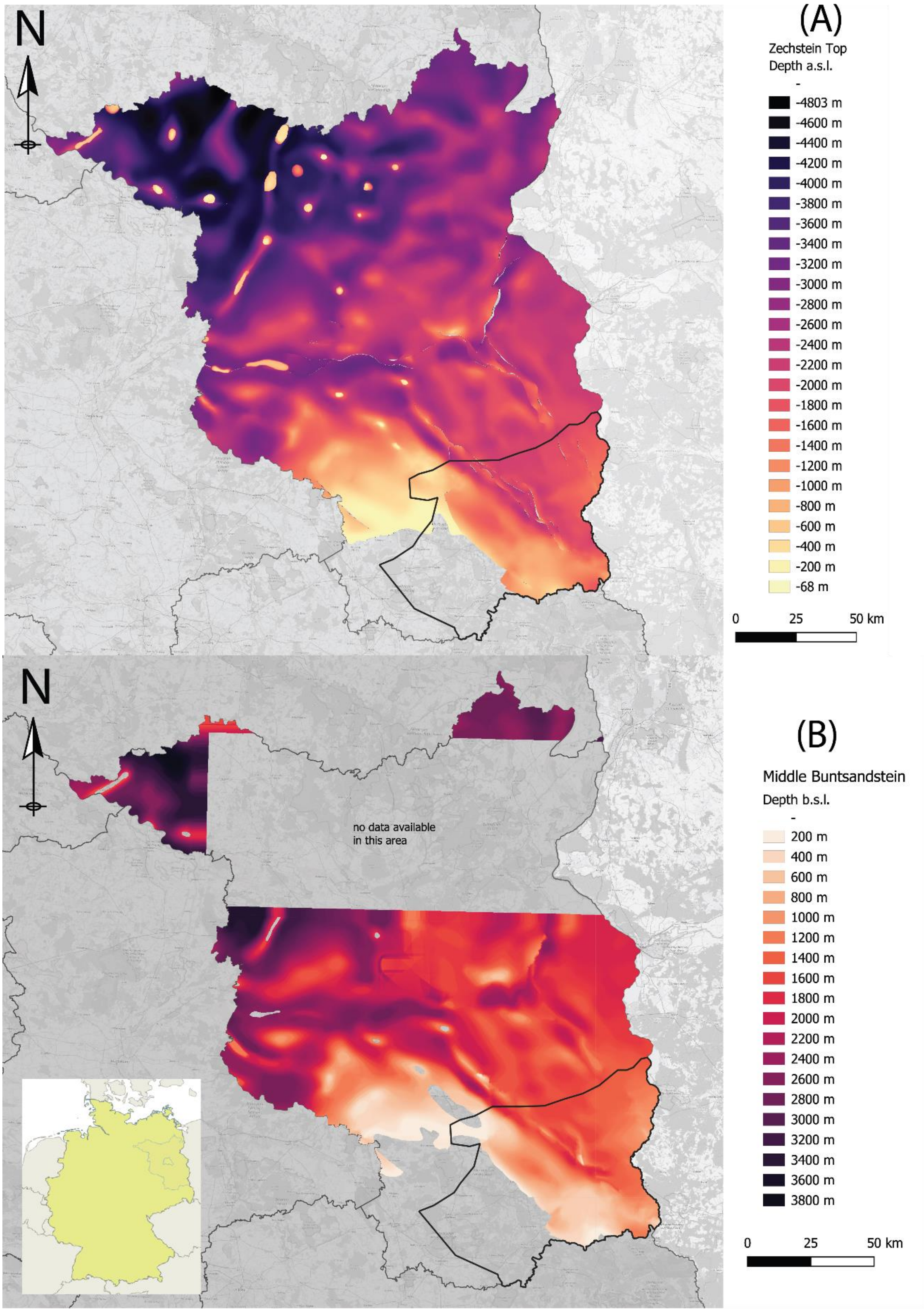


Figure 4.3: The distribution of (A) Top of Zechstein; (B) Bottom of Middle Buntsandstein in Berlin Brandenburg states (Modified after Diener et al., 1988-1992).

The base depth ranges from more than 3,500 m in the basin centre to less than 200 m at the southern margin, while thickness varies significantly depending on regional stratigraphic gaps below the Solling Formation and the basin position (Feldrappe et al., 2007). In Brandenburg, the Middle Buntsandstone exhibits cyclic alternations of sandy and pelitic deposits, particularly evident in Lusatia based on Burg Gt BuC 1/98 thermal water drilling. The sequence begins with a basal sandstone, followed by alternating layers of sandstone, siltstone, and claystone. Coarser fractions decrease northwards and upwards, with basal sandstones overlain by siltstones and claystones containing intercalated sandstone layers (Detfurth) and anhydrite (Hardegsen). The Solling Formation generally consists of a 15–20 m thick sandstone overlain by 20 m of claystone and an additional 25 m thick sandstone. Beutler (2004) notes that sand content in the Detfurth, Hardegsen, and Solling formations increases continuously northeast of the Rostock-Gramzow deep fault in the NE basin and in SE Brandenburg.

In the Burg Gt BuC 1/98 borehole, the Volpriehausen basal sandstone serves as an aquifer (Göthel, 2006). The Volpriehausen sandstone, typically 2–10 m thick, reaches more than 25 m near Usedom Island (Feldrappe et al., 2007). Based on grain size, the Detfurth basal sandstone—usually developed in two layers—and in some cases the Hardegsen basal sandstone in southern Brandenburg, are suitable as aquifers because they lack carbonate cement that would reduce pore space (Feldrappe et al., 2007). The Detfurth sandstone ranges from 5-12 m thick, increasing to 20–40 m in the NE basin (Vorpommern, Usedom), while the Hardegsen basal sandstone ranges from 2-12 m basin-wide and 20-50 m in Vorpommern (Feldrappe et al., 2007). Core and borehole measurements indicate porosities of 10-30%, with higher values in the northeastern North German Basin (Feldrappe et al., 2007).

4.3.2 The Schilfsandstein (Stuttgart Formation, Middle Keuper)

The Middle Keuper begins with the Lower Gypsum Keuper, corresponding to the Grabfeld Formation (Beutler, 1998). Göthel (2006) identified the Grundgips in the Burg GT BuC 1/98 thermal water borehole. Within the marls of the Lower Gypsum Keuper in the underground storage wells of the Ketzin structure west of Potsdam, locally thick Main Keuper rock salt with visible growth structures has developed. The Schilfsandstein Formation corresponds to the Stuttgart Formation (Raumer, 1998) and is associated with the Lunz Formation in Lower Austria. In Brandenburg, the Schilfsandstein Formation often includes coarser sandstone bodies that cut into the upper coarse sequence. The overlying, more silty deposits can transition into an upper coarse sequence of alternating finely layered siltstones and fine sandstones, ending with fine-grained medium sandstones. Due to its silty and finely layered nature, in which three coarser sandstone bodies of varying thickness—including some carbonate-rich layers—may occur, the Schilfsandstein Formation is only marginally suitable as an aquifer complex. The potential use of these coarser sandstone bodies as aquifers needs to be assessed on a case-by-case basis (Göthel, 2006), with channel facies of former river systems being potentially suitable. (Göthel, 2006).

As described by Feldrappe et al. (2007), the base of the Schilfsandstein Formation occurs at depths of 400-700 m along the southern and northeastern margins of the North German Basin, while in the basin centre it extends below 2,500 m. Maximum depths of 2,900-3,100 m are observed in depressions around salt domes in southern Mecklenburg, northern Brandenburg, and northern Saxony-Anhalt. In Mecklenburg-Western Pomerania, the formation reaches approximately 80-100 m in thickness, decreasing to 40-60 m in the more southerly regions (Beutler et al., 2005). Feldrappe et al. (2007) concluded that the Schilfsandstein Formation should be regarded as a complex aquifer with limited spatial distribution.

Drilling has shown that the sandstones of the Schilfsandstein Formation are sometimes distributed across several horizons, with thicknesses ranging from 5 to 60 m, particularly above salt domes such as the Schlieven structure in Mecklenburg. Thicknesses exceeding 60 m occur only in the northeastern part of the study area and in trench structures atop certain salt domes. The storage properties of the Schilfsandstein are generally limited; despite relatively high porosities of 20-35%, only moderate permeabilities of 40-130 mD are achieved in the described channel facies (Wolfgramm et al., 2008).

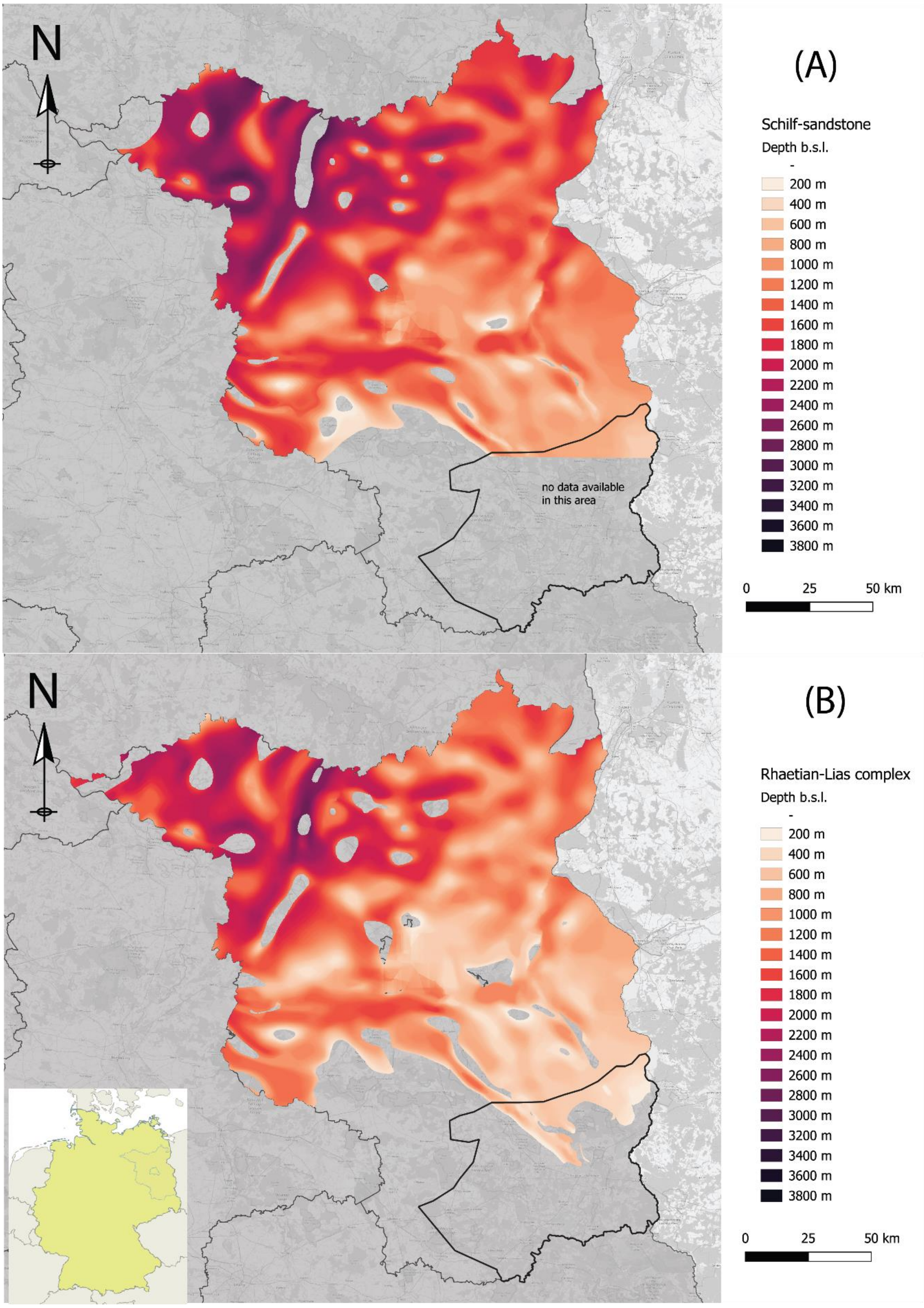


Figure 4.4: The distribution of (A) The base of Schilf Sandstone and (B) The base of Rhaetian-Lias Complex in Berlin Brandenburg states (Modified after Diener et al., 1988-1992).

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Consequently, aquifer productivity is low, reaching only 75–100 m³/h/MPa under exceptional conditions. Both Göthel (2006) and Feldrappe et al. (2007) concluded that the Schilfsandstein Formation should be regarded as a complex aquifer with limited spatial distribution.

4.3.3 Rhaetian – Lias complex

The Lias (Lower Jurassic) deposits in Brandenburg have been subdivided into bio- and chronostratigraphic units based on ammonite occurrences, following the work of Göthel (2006). These deposits can be correlated primarily with Lower Saxony, but also with the Subhercynian Basin in Saxony-Anhalt and, similarly to the Upper Keuper, with the Thuringian Basin. The Lias in Brandenburg is characterized by alternating sandstones, siltstones, and claystones, which allow classification as eustatic sequences. As a result of Old Kimmerian tectonic events, Hettangian deposits may discordantly extend into the Steinmergel Keuper. The oldest Hettangian sequences include a weakly developed lower coarse sequence, beginning with finely sandy siltstones and sometimes ending with fine sandy claystones. In the Vetschau Keuper depression (Lusatia), coal banks containing the megaspore *Nathorstisporites hopliticus* and Pachyteris papillosa in claystones indicate a mangrove depositional environment. The Oben-Grob and Unten-Grob sequences comprise interbedded fine sandstones and siltstones forming the highstand systems tract of 3rd-order eustatic cycles (He 1 and He 2). Sandstones from the upper Oben-Grob to lower Unten-Grob sequences form an economically exploitable aquifer, classified as Psilonoten sandstone. Red-colored claystones equivalent to the Schlotheimia angulata zone of northwestern Germany are present, though their exact distribution in Brandenburg is unclear; they may also occur in the Upper Sinemurian as a facies equivalent of the Pankarp Formation in Skåne, Sweden (Göthel, 2006).

As studied by Feldrappe, the Rhaetian, divided into three units, consists of colorful and grey-black claystones, as well as light to brownish mature sandstones (Beutler, 2005; Franz & Wolfgramm, 2008). Sandstones occur in the Postera layers (Lower Rhaetian), the Contorta layers (Middle Rhaetian), and, locally, in the Triletes layers (Upper Rhaetian). The thickness of the entire Rhaetian sequence ranges from approximately 50 metres at the edges of the North German Basin (southwestern Rügen and southern Brandenburg) to 150–170 metres in southwestern Mecklenburg, and locally reaches up to 250 metres (Beutler, 2004; Beutler et al., 2005). The lower to middle Lias sequence (Hettangian to Pliensbachian stages) is composed of claystones, siltstones, and sandstones. Claystones often contain thin intercalations of siderite or sandstone, and thin coal beds occur locally. On average, this sequence is 270–400 metres thick, with particularly high thicknesses exceeding 500 metres observed in southwestern Mecklenburg and subsided segments of the Vorpommern fault system (Petzka, 1999; Petzka et al., 2004).

The Hettangian sequence is characterized by massive sandstone intercalations, whereas fine-grained sandstones dominate the Sinemurian stage and the base of both the lower and upper Pliensbachian stages. These sandstones are widespread across the entire basin (Petzka, 1999; Göthel, 2006), with thickness generally increasing from west to east (Petzka et al., 2004).

The base of the Lias occurs at depths ranging from 100 metres to 2,800 metres. Large areas at the basin margins and atop several salt domes are relatively shallow, with depths less than 1,600 metres (Fig. 5a). Depths greater than 2,500 metres are uncommon and are mostly restricted to marginal depressions associated with certain salt structures in the central basin, particularly in southwestern Mecklenburg and northwestern Brandenburg.

4.3.4 Aalen sandstone – Middle Jurassic

According to Göthel (2006), the Dogger succession in Brandenburg corresponds to the Middle Jurassic and extends up to the basal Upper Jurassic with the Ornatenton. It consists mainly of siltstones, marls, fine-grained sandstones, and claystones, with sandstones dominating the lower part and pelitic deposits the upper part. The Upper Aalenian sandstones are particularly well developed, showing distinct cyclic sequences and forming an aquifer of economic significance. Bajocian deposits, in contrast, are thin and of limited aquifer potential. Bathonian strata are partly missing; where present, they include Cornbrash facies with oolitic iron ores, historically explored in Prignitz (Karstädt-Ost Fe KaO 11/3/62) and Potsdam (Potsdam Ug P S11/62). The Callovian sequence is composed of calcareous silty to clayey deposits, with Ornatenton clays in the Middle to Upper Callovian extending into the basal Upper Jurassic. Ammonites from boreholes (Oderin Kb Odn 1/62 and Kb Odn 2/62) provide biostratigraphic control, though many require taxonomic revision. Overall, the Dogger reflects marine transgressions, the influence of salt tectonics, and localized iron ore formation, with the most significant groundwater potential associated with the Upper Aalenian sandstones.

The Upper Aalenian (Middle Jurassic) sandstones, also known as Dogger-ß or Altmark sandstones, form a medium- to fine-grained aquifer with excellent storage properties. Porosity is typically 25–30% (sometimes higher), and permeability ranges from 500 to 1,000 mD, resulting in productivity values of 150–300 $m^3/h/MPa$ (Diener et al., 1988–1992; Wolfgramm et al., 2008; Feldrappe, 2008). Thickness varies considerably, from <20 m in the northeast to ~100 m in western and southern parts of the study area, as documented, for example, by the Gt Neuruppin 2/87 borehole in northern Brandenburg (Göthel, 2006). Maximum thickness occurs in eastern marginal depressions, such as the Werle salt dome in western Mecklenburg, reaching up to 270 m (Petzka et al., 2004). The sandstones are absent in large areas of Western Pomerania, western and northern Mecklenburg, northern Saxony-Anhalt, and southern Brandenburg. Depths to the base range from ~100 m at basin edges to 2,400 m in marginal depressions, with temperatures generally <60 °C, increasing locally near some salt domes (Feldrappe, 2008).

4.3.5 Lower Cretaceous

Feldrappe (2007) summarizes that, according to Diener (2000a, 2000b) and Diener et al. (2004), the Lower Cretaceous succession is dominated by clayey-marly sediments in the central parts of the depressions (North Altmark, southwestern Mecklenburg), whereas sandstones with intercalated claystone and marl layers are typical of the marginal areas (South Altmark, western Brandenburg) and the Usedom Depression. The total thickness of the Lower Cretaceous (Berriasian to Lower Middle Albian) varies from only a few meters in threshold regions to more than 1,000 m within marginal basins adjacent to salt structures in western Brandenburg. The base of the sequence is commonly encountered at depths of 500–1,500 m, although it occurs locally at shallower levels above salt domes.

In contrast, in marginal depressions around the Gülze-Sumte, Lübtheen, and Kaarßen salt domes (western Mecklenburg), the base descends to depths of about 3,000 m. The occurrence of deep Lower Cretaceous sandstones (Wealden and Valanginian) is restricted to a few marginal depressions in southwestern Mecklenburg and the Altmark, as well as the Usedom Depression and the Prerow Fault Zone, where they reach thicknesses of up to 50 m (Diener, 2000a, 2000b). Upper Lower Cretaceous sandstones (Hauterivian-Aptian) are confined to the Prerow Fault Zone (≈50 m), the Usedom Depression (≈100 m), and western Brandenburg. These sandstones exhibit favorable storage properties, with porosities ranging from 20 to 38% and permeabilities classified as moderate to good (250–1,000 mD).

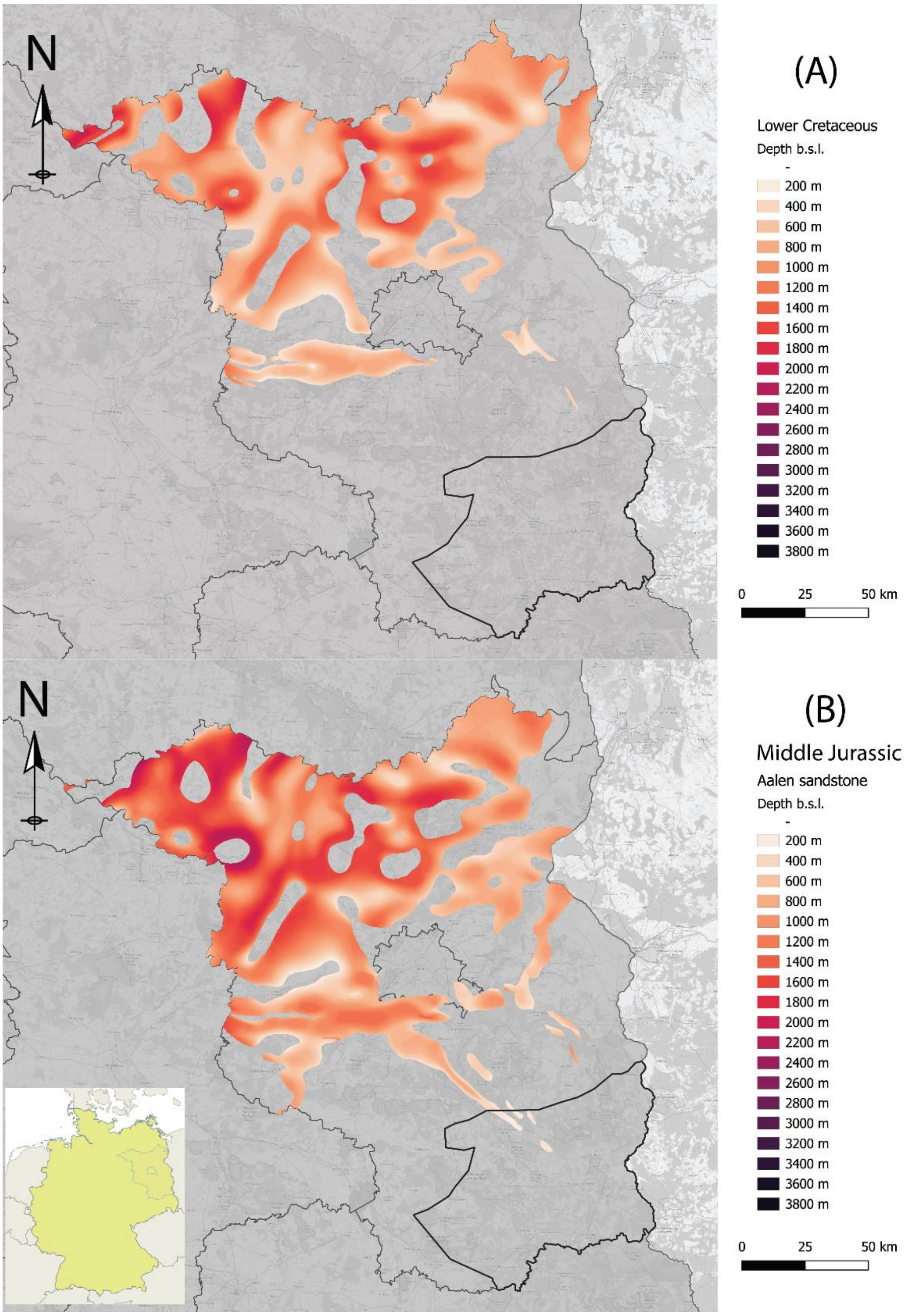


Figure 4.5: The distribution of (A) The base of Lower Cretaceous and (B) The base of Aalen Sandstone (Middle Jurassic) (Modified after DIENER et al., 1988-1992).

4.3.6 Conclusion of the potential aquifer in the Lausitz area

In the Lausitz region of the North German Basin, three potential aquifers have been identified: the Middle Buntsandstein, the Schilfsandstein and the Rhaetian-Lias complex. The Middle Buntsandstein aquifer is the most significant of these, as borehole data indicate that it extends widely across the area, stretching from north to south and from central Lusatia to the eastern border with Poland. This broad distribution suggests that the aquifer is likely to be present near Cottbus and Guben, which are focal points of the current study. In contrast, the Schilf sandstone and the Rhätian-Lias complex are much more locally distributed, being restricted to the northern part of the region. While their presence in the north of Guben cannot be entirely ruled out, it is considered relatively unlikely.

The Middle Buntsandstone is distributed at depths between 200 and 1400 metres below sea level (m b.s.l.) and can be as deep as 1800 m b.s.l. in the central part of the Lausitz area (**Figure 4.4b**). As it extends southwards to the south-eastern edge of the North German Basin, the base of the Middle Buntsandstone can be found at a depth of 200 m b.s.l. Though the distributions are limited in the northern part of the Lausitz area, the Schilf sandstone can be found at depths of around 200 to 800 m b.s.l., and the Rhätian-Lias complex exists at depths of around 200 to 600 m b.s.l.

5. Geothermal features of the potential location

5.1 Temperature Distribution vs Depth in the area

The most important feature of geothermal energy is temperature. As shown in **Figure 5.1**, the applications of geothermal energy for either power generation or direct use are very dependent on the temperature scales as classified in Lindal diagram. As for the Lausitz region, though the original basement was a part of the ancient volcanic system (350 – 500 Ma) in the region (**Figure 4.1**) consists of the Lausitz Anticline zone, The Görlitz Syncline Zone, and the Niederlausitz Depression, the focus of the study area is located in the depression are where the most of sediment bodies are deposited.

Temperature distribution data were obtained from the GEOTIS (Geothermal Information System) database (Agemar, 2022; Agemar et al., 2012). The database comprises approximately 11,000 wells (Agemar, 2022) and over 700 ground-level datasets (Agemar et al., 2012) and was used to develop a three-dimensional estimate of the subsurface temperature distribution in Germany. **Figure 5.2** shows the temperature distribution of Lausitz area in particular.

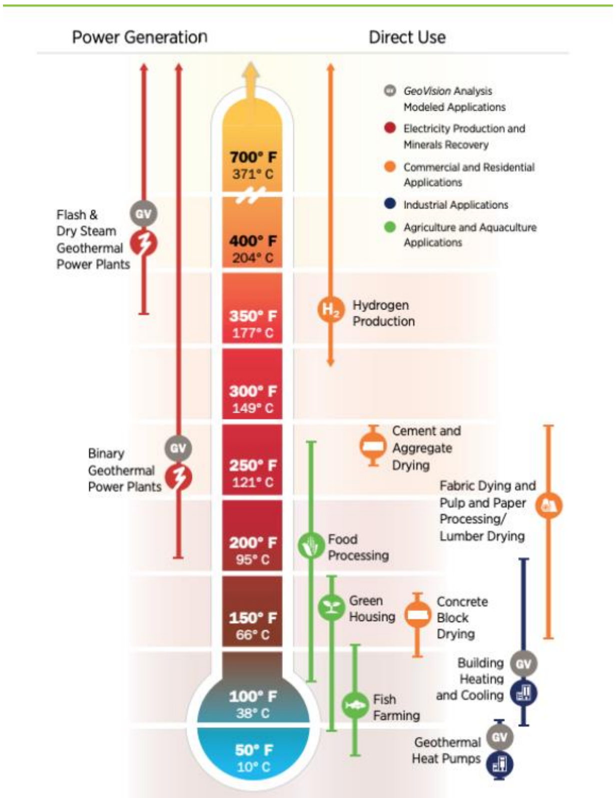


Figure 5.1: The continuum of geothermal energy technology applications and uses (U.S. Department of Energy, 2019). Source(https://www.energy.gov/sites/default/files/2019/06/f63/2-GeoVision-Chap2-opt.pdf)

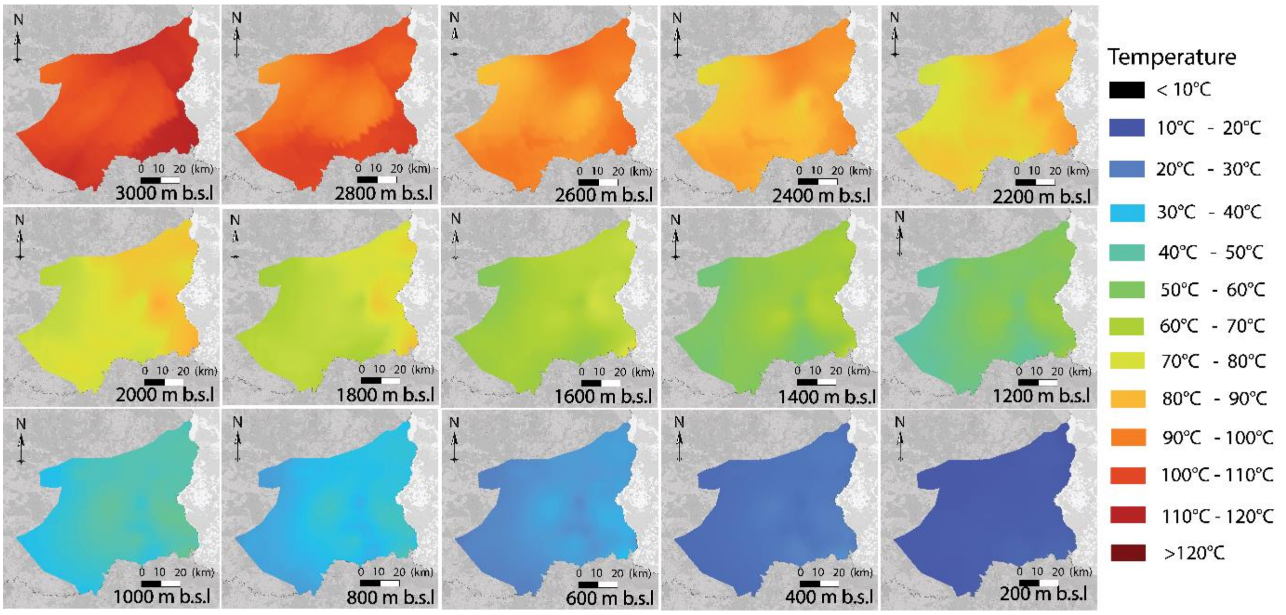


Figure 5.2: Temperature distribution in Lausitz region (Agemar et al., 2014). Source: https://www.geotis.de/geotisapp/geotis.php 1.12.2024.

Temperatures in excess of 110°C can be reached at depths exceeding 3,000 metres below sea level (m b.s.l.), as evidenced by the correlation of temperature data from thousands of boreholes. Temperatures ranging from 110°C to 80°C are found at depths between 2,200 m and 3,000 m b.s.l., while temperatures ranging from 80°C to 40°C are found at depths between 2,000 m and 1,200 m b.s.l. Temperatures range from 40°C to 10°C between 2,200 m and 1,200 m b.s.l.

Consistent with the presence of the previously mentioned potential aquifer, the expected temperature ranges from 20 to 40 °C at depths of 200–800 m b.s.l., where the Schilfsandstein and the Rhätian-Lias complex are more locally distributed in the northern part of the Lausitz region. However, for the Buntsandstein aquifer, the reservoir temperature could be expected to range from 40 to 80 °C. Of all these temperature ranges, the North German Basin has an average temperature gradient of 32 °C/km (Agemar, 2020, 2022). As it is also highly influenced by the presence of salt structures, the gradient depends on the distribution and thickness of the Zechstein formation and the flow of saline water.

5.2 Geothermal energy and thermal storage potential in the Lausitz area

Frick (2022) identified potential geothermal and thermal energy storage reservoirs within the North German Basin through a screening of available data focusing on Mesozoic formations with the workflow as described in **Figure 5.3**.

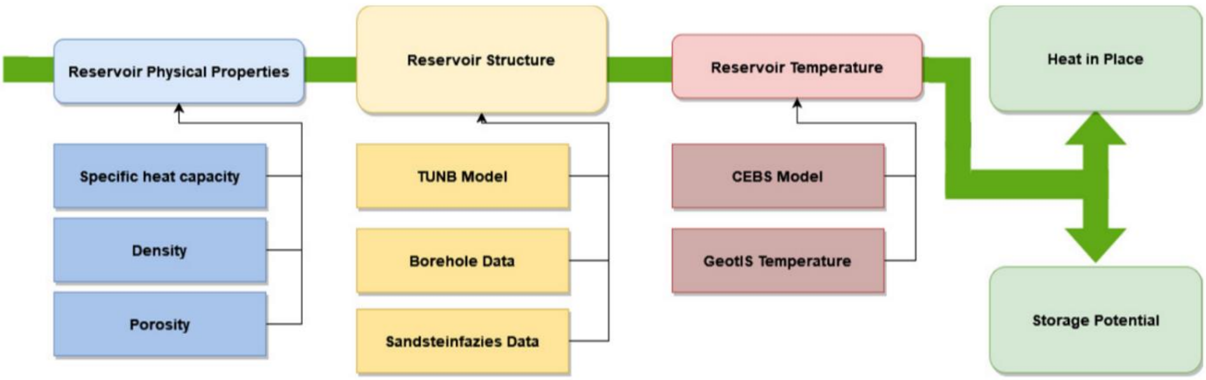


Figure 5.3: Applied workflow and data for Heat in Place and Storage Potential (Frick et al., 2022).

The analysis is based on [1] reservoir structure data includes: 3D geological and structural model, borehole data, and sandstone facies data; [2] reservoir physical properties: specific heat capacity, density, and porosity; [3] reservoir temperature: CEBS model, GeoTIS temperature. From these data, Heat in Place (HIP) and Heat Storage in Place (HSP) were derived. In the case of aquifer as a porous medium, the volumetric heat capacity $\boldsymbol{C_A}$ of the aquifer is given by the specific heat of the solid $\boldsymbol{C_S}$ and the liquid phase $\boldsymbol{C_w}$, and the porosity of the aquifer as the Equation (1).

$$\boldsymbol{C_A = \Phi \rho_w C_w + (1 - \Phi)\rho_S C_S} \quad \textbf{(1)}$$

HIP was calculated using the following Equation:

$$\boldsymbol{HIP = Q_{th} = V_A C_A (T_I - T_R)} \quad \textbf{(2)}$$

V_A is the reservoir volume, C_A is volumetric heat capacity of the aquifer, T_I is the injection temperature, and T_R is the temperature of the reservoir.

HSP was calculated using the following Equation:

$$\boldsymbol{HSP = Q_{th} = V_A C_A (T_R - T_I) F_r F_p} \quad \textbf{(3)}$$

F_r is packing correction factor, F_p is correction factor.

Formation	Thickness	Area	**Heat in place HIP (maximum) (GJ/m²)**	**Heat Storage Potential HSP (maximum) (GJ/m²)**
Lower Cretaceous	1973 m	1.20×10^3 km²	69,170.9	11,079.1
Middle Jurassic	1621.0 m	4.78×10^4 km²	3.914	6057.3
Lower Jurassic	1827.2 m	9.17×10^4 km²	3.949	12,951.1
Upper Keuper/ Upper Triassic	820.8 m	9.93×10^4 km²	3.688	6878.7
Lower Triassic (Middle Buntsandstein)	3111.6 m	1.48×10^5 km²	3.970	4878.1

Tabel 5.1: HIP and HSP calculation of formations comprising North German Basin (Frick, 2022).

Analysis reveals a strong positive correlation between reservoir depth, temperature, and predicted potential for High-Pressure, High-Temperature (HIP) systems: deeper, hotter reservoirs exhibit the greatest theoretical potential. Combining temperature data with detailed facies analysis of reservoir sandstones provides a powerful approach for guiding further exploration. Conversely, High-Pressure, Low-Temperature (HSP) systems demonstrate an inverse relationship, with shallower, colder reservoirs exhibiting higher storage potential. The temperature differential between the reservoir and injected fluid is a key factor influencing both HIP and HSP potential. For HIP systems, increased reservoir temperature directly translates to greater energy extraction, assuming a fixed reinjection temperature. For HSP systems, colder reservoir temperatures maximize the temperature contrast with the consistently injected 90°C fluid, resulting in higher predicted storage potential (**Table 5.1**).

According to Frick et al. (2022), the Jurassic reservoirs and the Middle Buntsandstein exhibit distinct geothermal characteristics, making them suitable for different applications. The Jurassic layers demonstrate versatility, offering good potential for both geothermal heat extraction and, notably, heat storage. Conversely, the Middle Buntsandstein displays moderate potential for heat extraction, particularly towards the basin margins, but is more limited in its storage capacity. This suggests the Middle Buntsandstein could be a localized resource for heat storage, but its overall contribution will be less substantial than that of the more widespread Jurassic formations. Consequently, Frick et al. (2022) highlight the Jurassic layers as the more versatile geothermal resource, while the Middle Buntsandstein offers potential in specific locations, particularly for extraction along the basin margins (**Figure 5.4**).

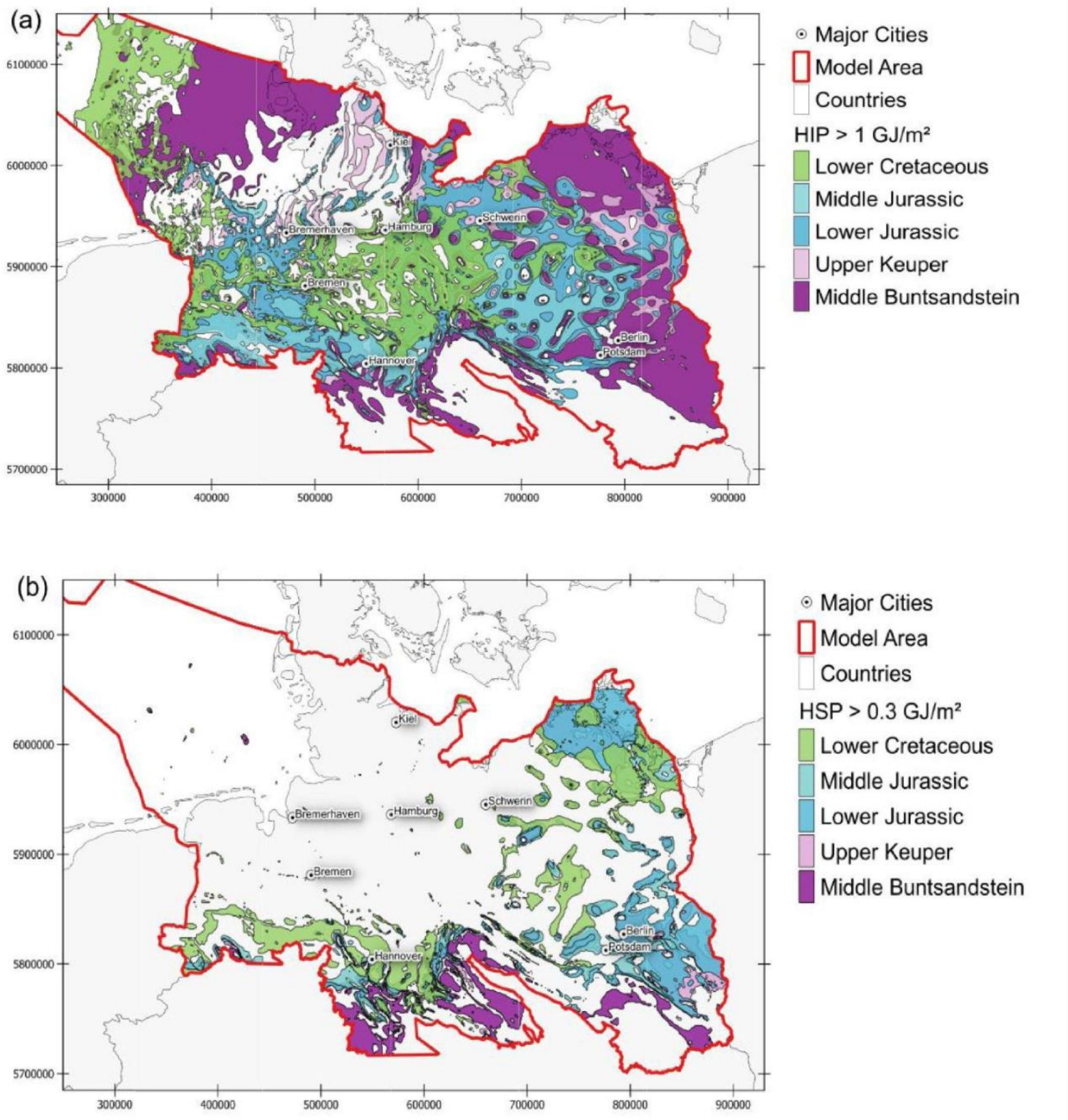


Figure 5.4: Areas of high geothermal potential in the North German Basin based on the temperatures from Frick et al. (2022): (a) Areas in the North German Basin with HIP larger than 1 GJ/m2 for each of the studied stratigraphic units; (b) Areas in the North German Basin with HSP larger than 0.3 GJ/m2 for each of the studied stratigraphic units; (a,b) Coordinates are in UTM Zone 32N. Color-coding after the youngest/shallowest encountered unit. Lower Cretaceous to Upper Keuper have 80% opacity to symbolize underlying reservoirs with high potential (Frick et al., 2022).

5.3 Correlation of reflection seismic horizon with aquifers, storage and barier complex in Brandenburg area

Figure 5.5 illustrates the correlation identified in Göthel's (2016) study, indicating that the most economically viable aquifers are concentrated in the northern and central regions of the Berlin-Brandenburg area. The aquifers in the Lausitz region date back to the Jurassic and Triassic periods.

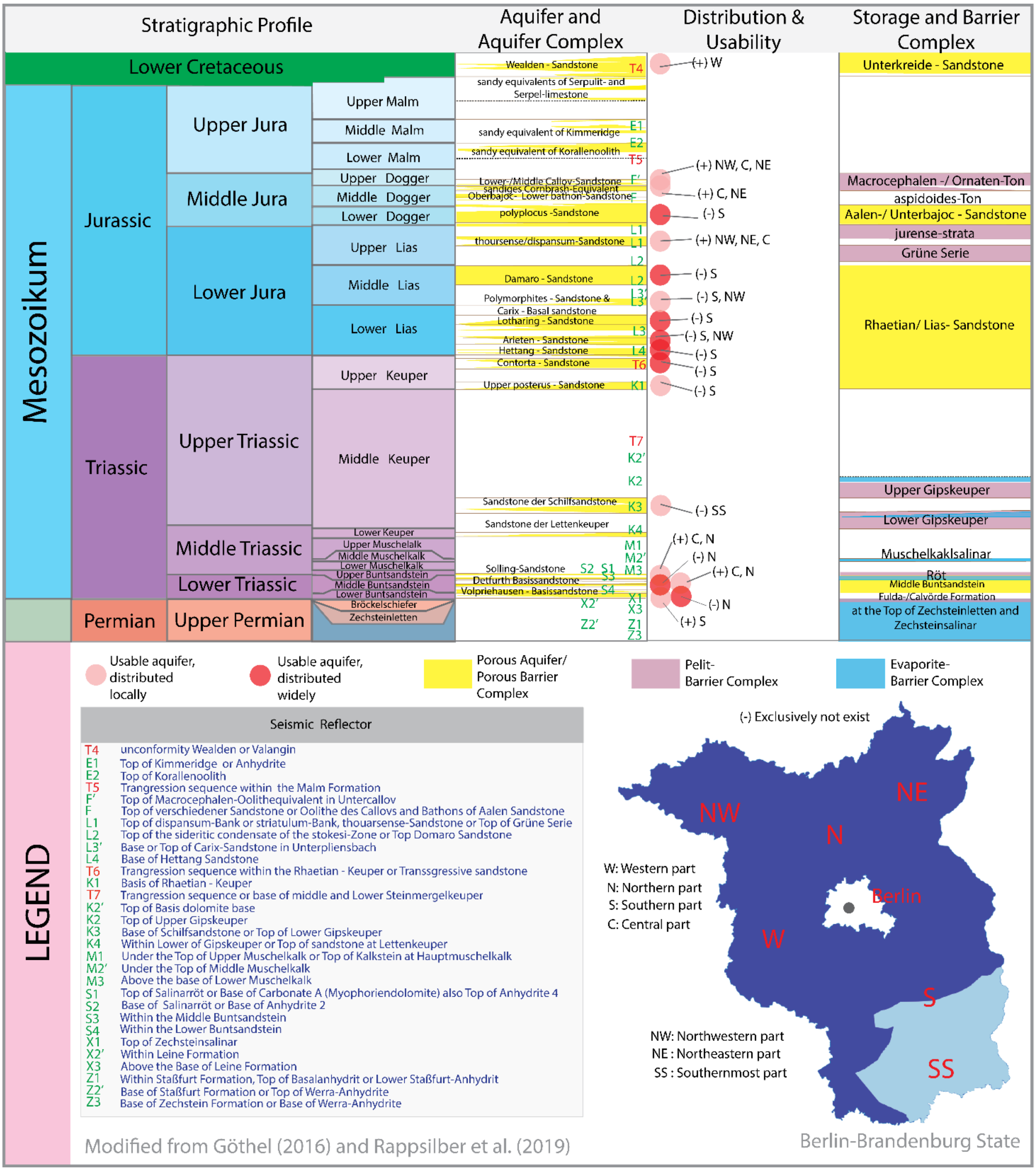


Figure 5.5: Seismic reflection horizon with aquifers, storage, and barrier complex correlation in greater Brandenburg area (Modified from Göthel, 2016).

These widely distributed aquifers are of Lower to Middle Jurassic age and comprise Polyplocus, Damaro (L2), Carix, Lotharing (L3), Arieten (L3), Hettang (L4), and Contorta (T6) sandstones, which are mostly found in the northern part of the Brandenburg area. Conversely, the Lower Triassic Detfurth (S3) and Volpriehausen (S4) sandstones are mainly found in the south of the Brandenburg region. Other potential storage aquifers, such as the Lower Cretaceous, Callovian, Cornbrash Equivalent, Oberbajoc-Lower Bathonian, Thorsense/Dispansum (L1) and Polymorphites (L3') sandstones (all Jurassic), are only locally distributed and absent from the southern part of the Lausitz study area. Similarly, some aquifers, such as the Solling (S2), Hardegsen (S3) and Bernburg sandstones (S4), are distributed locally in the southern part of the Brandenburg area.

Potential storage aquifers are identified in the Rhaetian/Lias and the Middle Buntsandstein (Figure 7). The most promising storage aquifers are evaluated based on the lithology, porosity and permeability of the formations themselves. Formations such as Zechstein (Zechsteinletten and Zechsteinsalinar) were also identified as potentially functioning as barriers in the southern part of Brandenburg, particularly in the Lausitz area. Formations such as the Upper and Lower Gipskeuper Formations do not exist as thick layers, but rather as thin barriers. Correlation is essential for evaluating the distribution of potential reservoirs alongside the availability of seismic data, which can later be translated into the potential depth of aquifers marked by seismic tracing when well data are unavailable.

5.4 Conclusion on the geothermal potential area related to storage applications

5.4.1 Potential site for thermal storage in the Lausitz region

The identification of a potential site for Underground Thermal Energy Storage (UTES) in the Lausitz region was predicated on a convergence of geological, infrastructural, and strategic factors as shown in **Figure 5.6**. Crucially, the site's selection benefits from its geographical proximity to the Jänschwalde power plant site and Heating power plant Cottbus (HKW GmbH site), a significant heat source for potential UTES integration. This proximity minimizes thermal losses during heat transfer, reducing overall system costs and enhancing efficiency. Furthermore, the presence of an established district heating network in the city of Cottbus (HKW GmbH site), provides a readily available thermal distribution infrastructure, obviating the need for extensive and costly pipeline development. Initial assessments indicate this network has sufficient capacity to accommodate the anticipated thermal output from the proposed storage facility.

Supporting this infrastructural advantage is comprehensive analogue well data, exhibiting both substantial depth penetration and complete stratigraphic profiles. This data from well E Bres 3/89, E Gu 12h/64, E Tau 101/65, E Lka 6/79 confirm the presence of economically viable aquifer formations, specifically the Rhaetian/Lias sandstone and Middle Buntsandstein, at depths conducive to efficient UTES operation. Analysis of these formations suggests favorable permeability and porosity characteristics, critical for achieving high storage capacity and recovery rates. At this juncture, optimization efforts are focused on minimizing the distance between the Jänswalde power plant and key supply points within the district heating network, this distance represents a pivotal parameter in determining the optimal location for the storage facility, balancing heat transfer efficiency with network integration costs. The proposed location is situated within the LEAG master plan area, ensuring alignment with regional energy strategy and facilitating potential synergies with existing energy infrastructure.

Figure 5.6: Location of potential site for thermal storage in Lausitz. Source: https://earth.google.com/. (Accessed October, 2025).

5.4.2 Lithological description for the well reference

5.4.2.1 Oil- and gas well E Tau 101/65

The Tauer well E Tau 101/65, with coordinates (UTM): 33U 463005,97; 5749684,49, an altitude of 63 m, and a final measured depth of 2342 m (TVD differs by 0,56 m), was drilled in 1965. It lies between the cities Cottbus and Guben in the northwestern part of the Lausitz region.

In this well the Cenozoic/Cretaceous limit can be encountered at a depth of 155 m (-92 m a.s.l.). The Cenozoic (Pleistocene to Tertiary) is composed of sands with clay-layers up to 45m, followed by fine-grained gravel, intercalated with lignite containing some silt and sand to 105 m and fine to coarse-grained sand and gravel up to 155 m. Cretaceous layers start with marl limestones (partly silty) of the Coniac, the upper, middle and lower Turon and Cenoman up to a depth of 403 m. Then, the Steinmergelkeuper claystones and marlstones and some percentage of marl-limestones up to 457 m depth. Underlying those, the upper Gipskeuper marlstones and marl-limestones occur with a lower percentage (around 10-15%) of claystones up to 510 m depth, and then claystones dominate in the next 20 m range (up to 530 m). Underlying, Schilfsandstone (Keuper) claystones, with a lesser content of marlstones, limestones and sandstones up to a depth of 590m. The Schilfsandstein sandstones occur from 590 to 610 m, but have percentages between 20 and 50 % of claystone. After another 6 m of Schilfsandstein claystones, the lower Gipskeuper claystones crop out mixed with lower contents of gypsum and anhydrite (up to 688 m depth). Lower Keuper claystones are next in the sequence up to 760 m depth, underlain by Oberer Muschelkalk claystones with percentages of marlstone and limestone. The middle Muschelkalk follow with claystones (+a percentage of limestone and marlstone and claystone) intercalated with limestones and anhydrite up to 805 m, followed by limestones with percentages of marlstone up to 1007 m. Below, Röt 3 limestones follow with some marlstone and claystone up to 1026 m, and the Kavernen-limestone from 1026-1032 m depth. Then the upper Graumergel Anhydrite 5 limestones and anhydrites occur up to 1050 m depth, underlain by anhydrite 4 and marlstones of the Graumergel-zone up to 1063 m depth. Afterwards marlstone of the Kalkcyclus C (8 m thickness), Rotmergelzone (16 m thickness) and Kalkzyklus B (12 m thickness) follows until a depth of 1099 m. Clayey anhydrite from the Anhydrit 3 sequence extends from 1099 – 1105 m. It is superimposed by 6 m thick marlstone from the Anhydrite 3 sequence, 22 m thick marlstone of the Kalkzyklus A and 17 m thick layer of anhydrite of the Anhydrite 2 sequence. The Rötsalz reaches from 1150 – 1173 m and consists of alternating layers of anhydrite-enriched halite and anhydrite, starting with 8 m halite, 4 m anhydrite and 11 m halite. The Anhydrite 1 sequence is a 11 m clayey anhydrite and a 3,6 m anhydrite at the bottom. It extends from 1173 – 1187,6 m depth and lies above the Middle Buntsandstein that includes permeable and porous sandstone horizons which are probably suitable for a geothermal exploitation.

Unfortunately, the sandstone formations in the strata catalog of the well E Tau 101/65 have not been stratified by its editor (or are not available for the LBGR). So, for this well it is not possible to distinct between Solling, Hardegsen, Detfurth, and Volpriehausen formation. At a depth of 1187,6 m (-1124,6 m a.s.l.) the Middle Buntsandstein has its top (**Figure 5.7**). Until a depth of 1201,1 m claystone and limestone with few thin sandstone layers dominate. An 8,4 m thick horizon with fine grained sandstone and thin insertions of silty claystone lies underneath, followed by a 5,5 m thick fine to coarse sandstone that contains 15 % clay, 5 % anhydrite and some lime. From 1215 – 1235 m depth exists a fine- to middle-grained sandstone layer that is rich in claystone (45%) and anhydrite (5%). In a depth of 1235 - 1250 m sediments with 40-50% sandstone, 40-50% claystone and 5-10% anhydrite occur. It is followed by a 20 m thick layer of silty claystone and a 10m thick fine sandstone with a high content in siltstone (25-30%), claystone (10-20%) and anhydrite (5-10%). In a depth of 1280 - 1330m are sediments with varying compositions in fine sandstone (35-45%), siltstone (10-30%), claystone (30-40%) and anhydrite (5-10%). They are followed by a 5 thick silty claystone. Beneath these are sandstone layers that appear to have good properties in terms of porosity and permeability, starting with a 5 m thick layer of fine- to middle-grained, crumbly, low carbonate-bearing sandstone with 10% claystone. 5 m below the clay content increases to 20% and 5 m further the sandstone content drops to 70% (20% claystone and 10% siltstone). In a depth of 1355 – 1360 m the sediment consists of 60% sandstone, 20% claystone, 15% siltstone and 5% anhydrite until the sandstone content increases again. From 1660 – 1680 m depth occur a fine- to middle-grained, crumbly, low carbonate-bearing sandstone with 10% claystone and 10% siltstone. These relatively pure sandstones occur in ranges of 1385-1390 m (75% sandstone, 15 claystone, 10 % siltstone), 1390 – 1400 m (80% sandstone, 10% claystone, 10% siltstone) and 1410-1416 (95 % fine- to coarse-grained sandstone, 5% claystone). In depths of 1380-1385 m and 1400-1410 m the sandstone content is 65 % with varying parts of claystone (20-25%), siltstone (10 %) and anhydrite (0-5%).

The Lower Buntsandstein reaches from 1416 – 1740 m and is not stratified too. At the top it contains relatively pure sandstones which have probably good properties in terms of its geothermal usage. They consist of 80 – 90% fine- to coarse-grained, crumbly, extremely low carbonate-bearing sandstone with 10 – 20% claystone. These layers extend from 1416 – 1455 m depth. Below follow 120 m thick horizons with varying contents of fine sandstone (50 – 75%), claystone (25 – 45%) and partial limestone before claystone dominates at a depth of 1585 m. Until a depth of 1680 m the claystone content does not fall below 50% (except at 1655-1660 m with a value of 40% claystone and 60% fine sandstone). After that, fine sandstone dominates. In ranges of 1680 – 1685 m and 1690 – 1695 m its content is 85% and 90% by 15% and 10% claystone. At 1685 – 1690 m the sandstone bears 40 % claystone, at 1700 – 1705 m 30% claystone, at 1705 – 1730 m 15% claystone with 5% limestone and from 1730 – 1740 m the sandstone has 25% claystone.

The Zechstein has its top at 1740 m depth and starts with the Aller-cycle. It consists of 4 m thick anhydrite, 15 m halite, 1 m anhydrite and 4 m claystone at the bottom. Then the Leine formation begins and reaches to a depth of 1958,4 m. Its cycle is characterized by an alternation of halite (3,5 – 113 m thickness), clay-and siltstone (1 - 4 m), anhydrite (0,8 – 18,5 m) and gypsum (1,5 – 25 m). The Staßfurt formation follows from 1958,4 – 2329,1 m. At the top is the Deckanhydrit with 2,6 m thickness, followed by Staßfurt rock salt until a depth of 2219 m (consits of anhydrite and calystone). The Basalanhydrite with anhydrite lies below and reaches a depth of 2219 – 2233 m. Dolomite of the Hauptdolomit is in a depth of 2233 – 2329,1 m and the bottom of the Staßfurt cycle. Afterwards, the borehole ends in the Upper Werra anhydrite of the Werra formation in a depth of 2342 m.

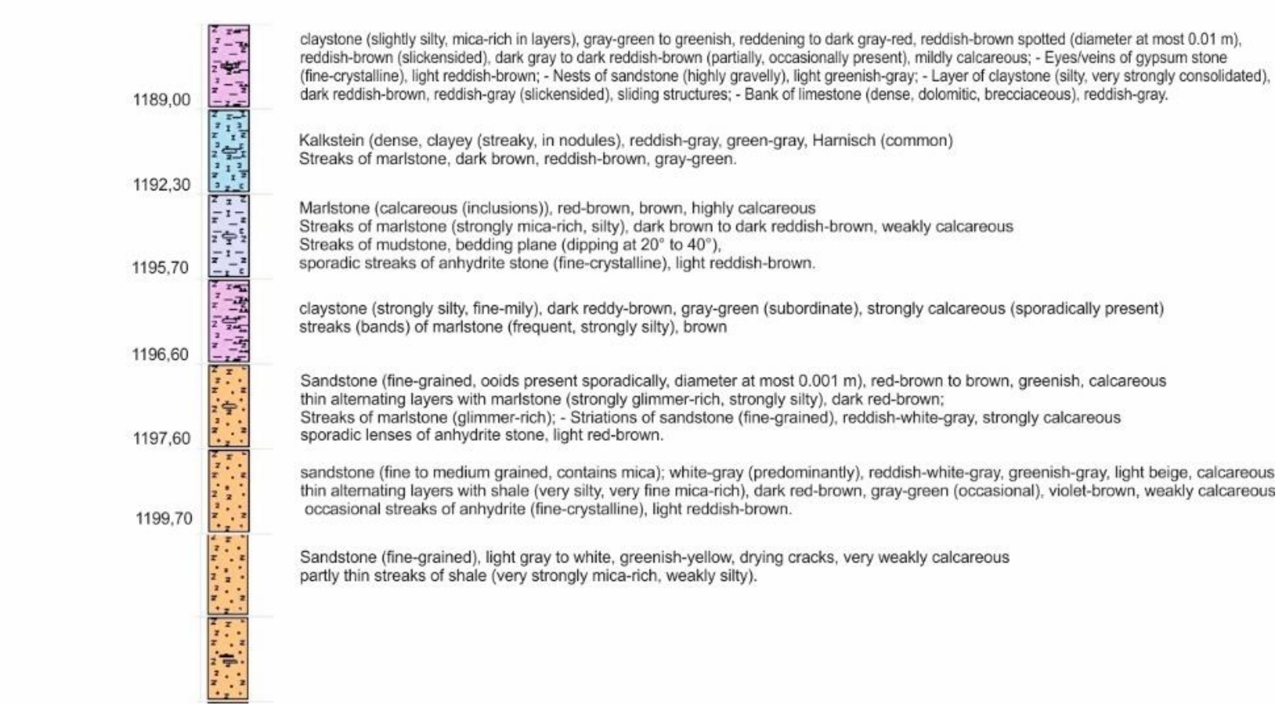


Figure 5.7: Lithology description of well E Tau 101/65 showing a starting of potential aquifer of Buntsandstein from a depth 1196.6 m. Source: well database of LBGR Brandenburg.

5.4.2.1 Oil- and gas well E Bres 3/89

The abandoned oil and gas well E Bres 3/89 is located ca. 10 km north of the city Guben. It has the UTM coordinates 33U 480332,91 5765533,61; an altitude of 54,3 m and a measured depth of 1880 m. The borehole was drilled as vertically as possible. The true vertical depth differs only by 0,12 m. **Figure 5.8** shows the current condition of the well E Bres 3/89 (05.03.2025).

Figure 5.8: Surface condition of well E Bres 3/89. Source: LBGR field survey, 2025.

In this well the Cenozoic extends to a depth of 198,5 m (-144,2 m a.s.l.). It consists of quarterny sediments from pleistocene from 0 to 56 m which are mainly characterized by glacial and warm period deposits like fine and coarse sand and boulder clay with fine grained gravel. It is followed by the Tertiary which reaches from 56 - 198,5 m depth. It contains the 61m thick Miocene with silt and xylithic lignite of the Briesker layers and the Oligocene from 117 - 198,5 m with fine sand to fine gravel of the Cottbus layers.

From 198,5 – 1608,5 m the Triassic formation underlies the Cenozoic formation. The Cretaceous and Jurassic periods have been completely eroded in the area of the well. The Triassic begins with the 91.5-metre-thick Postera layers of the Upper Keuper. This unit is a potential aquifer and could be exploited for geothermal energy, but in this region the Rhaetian consists only of claystone and siltstone. These rocks overlie the base dolomite of the Upper Keuper, which ends at 326 m, and are followed by the 82 m thick layer of claystone of the Upper Gipskeuper of the Middle Keuper, and the Schilfsandstone of the Stuttgart Formation at depths of 408–467 m. The Schilfsandstein is known as a potential aquifer, but in the E Bres 3/89 area it consists of poorly porous and permeable clayey siltstone and claystone. The Lower Gipskeuper occurs from 467 to 543 metres and consists of gypsum and clayey siltstone. The Lower Keuper consists of the Lettenkeuper sequence from 543–588 m depth, comprising a 2-m-thick dolomite bank, 15-m-thick upper red-brown claystones, 16-m-thick Hauptletten coal-sandstone, and 12-m-thick lower red-brown claystones. According to Feldrappe et al. (2008), the Hauptletten-coal sandstone could be suitable for geothermal usage, but it consists of 8 m of claystone and only 8 m of fine sandstone, which is rich in silt and carbonates. The Keuper formation is followed by the Muschelkalk formation from 588 to 876 metres depth. The alternating sequence of claystone and claymarlstone of the Upper Ceratiten layers (588–627 m), the limestones and marlstones of the Middle Ceratiten layers (627–658.5 m), and the limestones of the Lower Ceratiten layers (658.5–665.5 m) form part of the Upper Muschelkalk. The Middle Muschelkalk extends from 665.5 to 732 m and consists of anhydrite sequences containing anhydrite, dolomite, and dolomite-marlstone. The underlying Wellenkalk sequence belongs to the Lower Muschelkalk. These limestones occur from 732–876 m. Below the Muschelkalk is the 732.5 m thick Buntsandstein. This begins with the calystone and clay marlstone of the Myophorien sequence (876–903 m) and the Pelitröt sequence (903–999 m). The Pelitröt also includes anhydrite from the Sulfat 3 sequence at a depth of 967–976 m, as well as Myophorien dolomite limestone from 976–999 m, so it is not suitable for geothermal exploitation either. The Salinarröt sequence, which is composed of anhydrite and rock salt, is found at a depth of 1014–1048 m and superimposes the 6 m thick anhydrite of the Sulfat 1 sequence. At a depth of 1054 m (-999,7 m a.s.l.), the middle Buntsandstein occurs. It contains several sandstone layers that serve as aquifers as shown in Figure 5.9.

Starting at 1054–1077 m, it comprises the 18 m thick Solling alternating sequence, consisting of fine-grained siltstone, claystone and fine sand. This is underlain by 5 m of silty fine sandstone. The Hardegsen sequence follows the Solling sequence at a depth of 1077–1115 m and is composed of alternating layers of silty claystone and fine sandy siltstone (17 m thick) of the Hardegsen alternating sequence, as well as Hardegsen sandstone (21 m thick) at a depth of 1094–1115 m. The Detfurth sequence occurs at depths of 1141–1162 m and starts with alternating layers of fine sandstone with a low carbonate content and very fine sandy siltstone. The clay fraction increases towards the bottom. This horizon is known as the Detfurth alternating sequence (1115–1141 m) and is followed by the Detfurth sandstone, which is probably suitable for geothermal exploitation. This is a 21 m thick fine sandstone with a low carbonate content. Another possible aquifer is located at a depth of 1248–1278 m and consists of Volpriehausen sandstone, which is a fine sandstone with an increasing content of silt and carbonate at the bottom. This sandstone is located beneath the Volpriehausen alternating sequence, which consists of slightly carbonate fine sandstone and clayey siltstone.

1072,00	Solling-Wechselfolge Schluffstein (feinsandig), dunkelgrau bis grau - wechsellagernd mit Tonstein, dunkelgrau, rotbraun, grüngrau - wechsellagernd mit Feinsandstein (schluffig), hellgrau bis grau
1077,00	Solling-Bausandstein Feinsandstein (schluffig), hellgrau bis grau, hellbraun
1094,00	Hardegsen-Wechselfolge Tonstein (schluffig), dunkelgrau, rotbraun bis dunkelrotbraun - wechsellagernd mit Schluffstein (feinsandig), rotbraun, grau - im Hangenden Feinsandstein (schluffig), hellgrau bis hellgraubraun
1115,00	Hardegsen-Sandstein Feinsandstein, hellgrau bis grau, bräunlichgrau - wechsellagernd mit Schluffstein, grau, rotbraun
1141,00	Detfurth-Wechselfolge Tonstein, rotbraun, dunkelgrau bis grau, grüngrau bis dunkelgraugrün - wechsellagernd mit Schluffstein (stark feinsandig (teilweise), tonig (unten zunehmend)), grau bis dunkelgrau, rotbraun
1162,00	Detfurth-Sandstein Feinsandstein, hellgrau bis hellgraubraun, schwach kalkhaltig
1248,00	Volpriehausen-Wechselfolge Feinsandstein, hellgrau bis grau bis bräunlichgrau, schwach kalkhaltig - wechsellagernd mit Schluffstein (tonig), grau bis dunkelgrau, rotbraun bis dunkelrotbraun, graugrün
1278,00	Volpriehausen-Sandstein Feinsandstein (schluffig (unten zunehmend)), hellbraun bis hellrotbraun, hellgrau bis grau, kalkhaltig

Figure 5.9: Lithology description of well E Bres 3/89 showing a starting of potential aquifer of Buntsandstein from a depth of 1077 m. Source: well database of LBGR Brandenburg.

The Lower Buntsandstein extends from 1278 to 1608.5 m. The upper part of this formation is the Bernburg sequence, consisting of 156 m of alternating siltstone, claystone, and fine sandstone. The lower part consists of alternating siltstone, fine sandstone, and claystone, with several limestone banks and anhydrite layers from the Nordhausen sequence (1434–1608.5 m).

The top of the Zechstein (Permian) is located at a depth of 1608.5 m (-1554.2 m a.s.l.). This consists of:

- 4 m of the Ohre Formation (anhydrite (1 m) and halite (3 m))
- 30.5 m of the Aller Formation (halite, anhydrite (1 m) and claystone (2 m))
- 82 m of the Leine Formation (halite with some anhydrite layers (69 m), anhydrite (10 m) and claystone (3 m))
- 125 m of the Staßfurt Formation (pottash seam (12 m), halite (66 m), anhydrite (8 m) and dolomite (39 m))
- 30 m of the Werra Formation (anhydrite)

The final depth of the E Bres 3/89 well is 1880 m.

5.4.2.3 Oil- and gas well E Lka 6/79

The abonded oil and gas well E Lka 6/79 is located ca. 5 km northeast of the city centre of Cottbus, near the town Willmersdorf. It has the UTM coordinates 33U 458069,41 5740420; an altitude of 63,2 m and a measured depth of 2160 m. The true vertical depth differs by 17,99 m.

The Cenozoic of the well E Lka 6/79 reaches a depth of 154 m (-90,8 m a.s.l.) and consists of pleistocene fine sand and fine gravel of the Quaternary to a depth of 55 m, miocene lignite, fine gravel, middle- to coarse grained sands and silt of the Briesker-layers to a depth of 106 m and oligocene middle- to coarse grained sands and lignite of the Cottbus-layers to a depth of 154 m. The Cenozoic lies at the Upper Cretaceous that extends until 647 m. It is dominated by clay marlstones, marlstones, limestones and lime marlstones of the Coniacian (154 – 306 m), Turonian (306 – 631 m) and Cenomanian (631 – 647 m). These rocks are superimposed by the Triassic, starting with the Upper Keuper and its silt- and claystones of the Upper Postera-layers (647 - 663 m) and Lower Postera-layers (663 – 720 m) which are not suitable for geothermal exploitation. It is followed by the Basisdolomit with a 40 m thick layer of claystones, clay marlstones and siltstones until the bottom of the Upper Keuper is reached at 760 m. The Middle Keuper starts with the Upper Gipskeuper from 760 – 841 m depth and its anhydrite, clay- and siltstones. It is followed by the 56 m thick Schilfsandstein. Due to the occurrence of exclusively clay- and siltstones and a moderate carbonate content, this horizon is not suitable as a geothermal aquifer. The underlying Lower Gipskeuper reaches to a depth of 962 m and is composed of silt-, claystone and anhydrite. The Lower Keuper occur from 962 – 1005 m. Its clay marlstones, clay- and siltstones of the Grenzdolomit (962 – 965 m), Upper Rotbraune Tonsteine (965 – 975 m), Hauptlettenkohlensandstein (975 – 993 m) and Lower Rotbraune Tonsteine (993 – 1005 m) are superimposed by the Muschelkalk. The Hauptlettenkohlensandstein cannot therefore serve as a geothermal aquifer. The Upper Muschekalk consists of silt-, claystone and lime siltstones of the Upper Ceratiten-layers (1005 – 1027 m), lime marlstones, marlstones and clay marlstones of the Middle Ceratiten-layers (1027 – 1039 m) and limestone to lime marlstone of the Lower Ceratiten-layers and Trochitenkalk (1039 – 1058 m). It is followed by a 70 m thick alternating series of anhydrite and dolomite of the Middle Muschelkalk. The Lower Muschelkalk starts at 1128 m. Its lime marlstones, limestones and clay marlstones of the Upper Wellenkalk (1128 – 1195 m), the Oolithzone (1195 – 1205 m) and Lower Wellenkalk (1205 – 1265 m) lie on the silt- and claystones of the Myophorien-layers of the Buntsandstein. In a depth of 1288 m, a fault occurs with an offset of approximately 30 m. Afterwards the Pelitröt starts with the Graumergelzone to a depth of 1288 – 1310 m with clay-, siltstones and marlstones, the Sulfat 3 with an 8 m thick layer of anhydrite and the Myophoriendolomit with clay-, siltstones and marlstones that extends to a depth of 1339 m. At the bottom of the Upper Buntsandstein is a 35 m thick horizon of anhydrite of the Salinarröt.

The middle Buntsandstein starts at 1374 m with the Solling formation. The Solling-alternating sequence is composed of 3 m claystone, followed by 9 m alterateing clay- and siltstone and a 4 m thick claystone to clay marlstone with a high concentration of heavy metals. The Solling sandstone reaches from 1390 – 1395 m and consists of a silty fine sandstone with a moderate carbonate content. Below starts the Hardegsen-alternating sequence which is a horizon of 5 m siltstone at the top, 2 m claystone, 2 m fine sandstone and 5 m claystone at the bottom. In a depth of 1409 – 1429 is the Hardegsen sandstone localized. But like the Solling sandstone, it has similar poor properties as a potential geothermal aquifer. It consists of 16 m alternating silt-, claystone and fine sandstone and 4 m of carbonate free fine sandstone. The Detfurth formation is composed of 10 m lime marlstone, 6 m claystone of the Detfurth-alternating sequence and 15 m of silty fine sandstone with partially low content of carbonates. The Detfurth sandstone is underlain by the Volpriehausen formation that starts at 1460 and reaches a maximum depth of 1553 m (**Figure 5.10**). 93 m of this is the Volpriehausen-alternating sequence with 85 m siltstone and 8 m fine sandstone to siltstone. It is followed by the Volpriehausen sandstone which contain 6 m of middle-grained to silty fine sandstone, 16 m of silt to fine sandstone with several claystone layers and 7 m of siltstone. The carbonate fraction increases to the bottom of the Volpriehausen sandstone.

The Lower Buntsandstein starts at 1582 m of depth with the Bernburg formation which is a 149 m thick layer of silt- and claystones. The Nordhausen formation follows at 1731 m and is also composed of clay- and siltstones until a depth of 1887 m is reached. The underlaid Zechstein has anhydrite, halite and claystone of the 7 m thick Ohre formation at its top. It is followed by the Aller formation from 1894 – 1920 m with 21 m halite, 2 m anhydrite and 3 m claystone. This horizon is superimposed by the Leine formation and its 130 m thick evaporites. The Staßfurt formation reaches from 1050 – 2143,2 m and consists of halite, claystone, anhydrite and dolomite. The Werra formation is penetrated by the well too. At a depth of 2143,2 to the end of the borehole at 2160 m anhydrite is encountered.

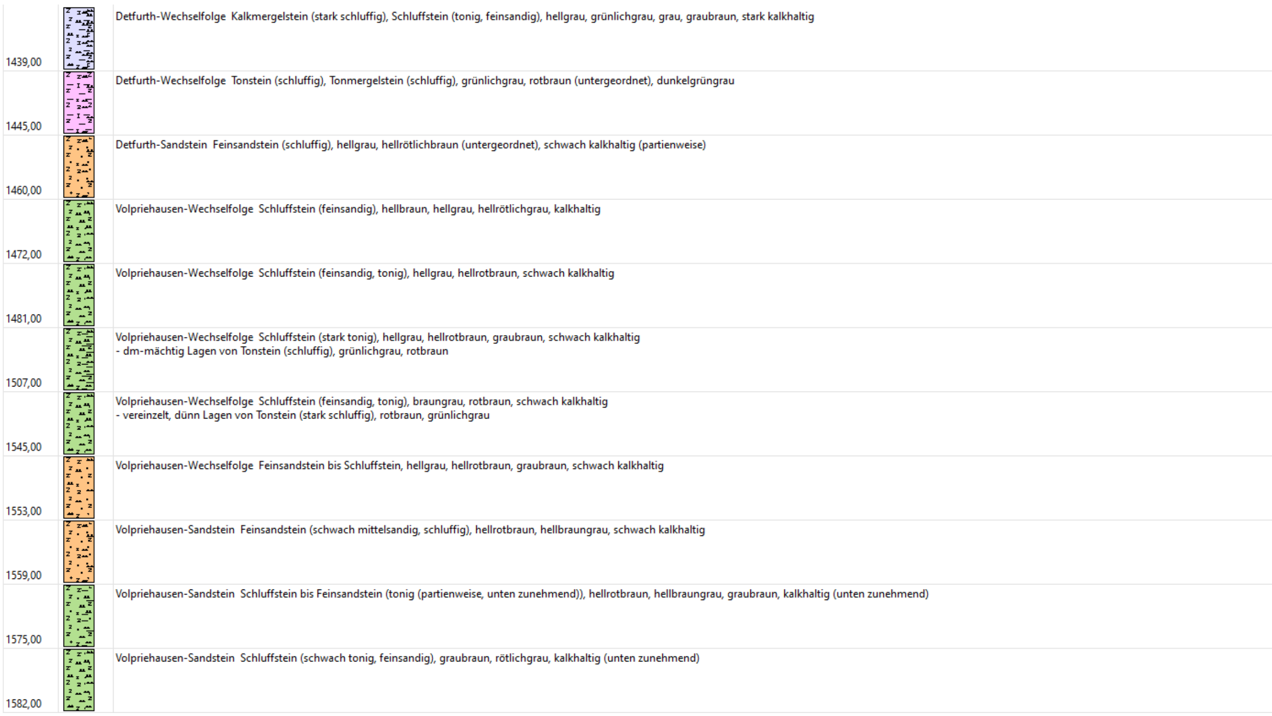


Figure 5.10: Lithology description of well E Lka 6/79. Source: well database of LBGR Brandenburg.

5.4.2.4 Oil and gas well E Gu 12h/64

Well E Gu 12h/64, an abandoned oil and gas borehole located approximately 5 kilometres southwest of Guben, provides valuable insight into the subsurface geology of the Lusatia region. The well is situated at UTM coordinates 33U 475793, 5752026, with an altitude of 58.1 m a.s.l. Drilled with a high degree of verticality (a deviation of only 0.5 meters from true vertical), the well reaches a measured depth of 1,785.1 meters (1727 meters b.s.l.) penetrating a significant stratigraphic sequence.

The stratigraphic sequence encountered in well E Gu 12h/64 reveals a predominantly sedimentary profile, characterized by alternating layers of sandstone, siltstone, claystone, anhydrite and carbonate formations indicative of a complex depositional history. Above the Buntsandstein, as in the other boreholes mentioned here, no lithological unit is suitable as a geothermal aquifer. The Middle Buntsandstein starts at a depth of 994 m (935,9 b.s.l.) and reaches to a depth of 1208 m (1149.9 m b.s.l.). Sediment with 75% of sandstone and 25% claystone represents the uppermost part below 1 m of claystone- and anhydrite-dominated rocks. In the following 5 m (1000 – 1005 m depth) the share of claystone increases to 40%. The percentage of claystone reaches values of 60 - 75% until a depth of 1031 m, excepting a 3 m thick sandstone layer between the depth of 1026 - 1029 m. It is followed by sandstone-dominated horizons with 60% sandstone and 40% claystone in the range of 1031 – 1035 m, 70% sandstone, 15% siltstone and 15% claystone in the range of 1035 – 1040 m and 50% sandstone, 20% siltstone and 30% claystone in the range of 1040 – 1050 m. A 20 m thick horizon of granular limestone (German: Rogenstein) superimposes. Granular limestone represents for a part of 60% the following 5 m in the well before sandstone occurs at 1075 m. The 11.4 m thick layer is intersected with thin clay- and siltstone layers. The next 3.1 m section is composed of fine-grained sandstone with almost exclusive quartz grains. On its bottom a 0.3 m layer with radially arranged anhydrite crystals occurs. Fine- to middle-grained sandstone, containing some thin layers of claystone (predominantly on slickenside surfaces) and iron oxides and -hydroxides at the bottom, is located at a depth of 1089.5 to 1135 m. The lowermost part of the middle Buntsandstein is dominated by claystone (60 – 80%). Below this, the Lower Buntsandstein (approximately 1215–1505 m of depth) is defined by a prevalence of claystone, a fine-grained sedimentary rock, signalling a shift in depositional environment. This formation gradually transitions upwards into the deeper Zechstein Carbonate and Evaporite Sequence (1505–1785.1 m), marking a fundamental change in sedimentary conditions. The transition zone (1505-1520 m) denotes the base of the sandstone and the onset of the Zechstein succession, beginning with initial carbonate and evaporite deposition in the Kalkstein/Aller-Steinsalz. This gives way to the Leine-Steinsalz (up to 1660 m), distinguished by persistent anhydrite layers indicating prolonged periods of evaporitic conditions and restricted marine circulation. Above this lies a thick sequence of dominant anhydrite deposits constituting the Hauptananhydrit (1660–1785.1 m). Finally, the borehole terminates within the Staßfurt Karbonat at 1785.1 m depth, representing the final carbonate deposition within the Zechstein sequence.

6. Proposed location for detail exploration and investigation

6.1 Cross section of interest area

Based on the lithological descriptions in the previous chapter, this study estimates the vertical distribution of potential Seasonal Thermal Energy Storage (UTES) using a 3D geological model of the Brandenburg cross-section. The thicknesses and depths of potential storage horizons are traced using available seismic data, specifically focusing on the geological formation between the Röt Formation and the Upper Buntsandstein Formation (S1), and the top of the Zechstein Formation (X1).

6.1.1 Cottbus and North of Cottbuser Ostsee area

6.1.1.1 Limberg-Guben area.

As shown in **Figure 6.1**, the study area extends for around 40 km from southwest to northeast, passing through the Limberg-Guben region and the Lakoma (E L Ka 6/79), Tauer (E Tau 101_65) and Guben (E Gu 12h_64) localities. The Buntsandstein exhibits a relatively consistent depth distribution ranging from -800 m to -2160 m below sea level (a.s.l.) with an average of 600 m thickness. At this depth the reservoir temperature is estimated at around 40°C to 80°C. The southwestern part of the area is characterised by intense fault zones, as evidenced by significant horizon displacement within the B2-T2, K2, M1 and S1 stratigraphic units. Areas containing reference hydrocarbon wells appear to be structurally undisturbed, which suggests that the fault systems around Guben and Limberg may function as stratigraphic traps for these sedimentary sequences. This area is considered suitable for the UTES site due to its proximity to the district heating network, which connects Cottbus and Guben at surface level and is approximately equal to the heating demand.

6.1.1.2 Tauer-Laubsdorf area.

The Tauer-Laubsdorf cross section extends from north of Jänschwalde, using well E Tau 101-65 as a northern reference, and trends southwards towards the western shore of Lake Cottbuser Ostsee. As shown in **Figure 6.2**, sediment thickness decreases towards the south, coinciding with uplift of the basement. Consequently, sediments in the southern part of the cross section are generally found at shallower depths. Several fault zones were identified immediately south of Tauer and in the northern area around the Cottbuser Ostsee, exhibiting a near-perpendicular orientation to the cross section. Within the area between Tauer and the northern part of the Cottbuser Ostsee, the Bunter Sandstone is relatively evenly distributed, with a thickness of approximately 600 metres at a depth of between -1,200 and -1,800 metres above sea level, and a temperature range of between 40°C to 80°C. This **zona** area is particularly strategic, as it crosses the Jänschwalde region, which features a well-developed electricity grid and district heating network**.**

6.1.1.3 Drebkau-Forst area

As shown in **Figure 6.3**, the Drebkau area extends from the southwestern part of Cottbus to the Forst area. The basement is uplifted in the southwestern portion of the cross section exposing Zechstein and Rotliegend (Potentially basement) to the shallower depth, resulting in shallow and thinly deposited sediments. The area between Drebkau and Forst is characterized by faulting, while the basement deepens towards the northwest, approaching the Polish border. However, this cross section remains the southernmost extent of the Cottbus area. The Bunter Sandstone thickens to a maximum of 1000 m at a depth between -900 and -2100 m a.s.l. This depth range corresponds to temperatures of approximately 50 °C to 90°C . However, the location is somewhat removed from the district heating network of Cottbus City.

6.1.1 Guben area

The potential study area is located on the border between Germany (Lausitz) and Poland. It extends from north of Breslack to south of Guben (**Figure 6.4a**) and towards northern Cottbus from Guben. The area is divided into three zones: Lieberose (north of Guben; **Figure 6.4b**), Lieberose-Guben (**Figure 6.4c**) and Fehrow-Prjawoz (south of Guben). The cross-section reveals that the area between the E Bres 3/89 reference well and the south is relatively undisturbed by faults, with slight basement uplift towards the south. The average thickness of the Buntsandstein formation in this zone is 700-800 metres at depths ranging from -600 to -2,000 metres above sea level, with estimated temperatures of 30-80 °C. This area extends for around 25 km.

In contrast, the east-west trending zone towards northern Cottbus is dissected by faults (Figures 6.1b and 6.2c). While the average thickness remains comparable, the sediments thicken slightly to the east between Lieberose, northern Guben and central Guben.

Further south, a west-east cross-section passing through Tauer and southern Cottbus reveals intense fault zones immediately to the south of Tauer. This aligns with the structural features shown in **Figure 6.1** and **Figure 6.2**, which are particularly pronounced in the western part of Lakoma and to the south of Tauer. In this area, the thickness of the Buntsandstein ranges from 400 to 600 metres at depths of between -1,250 and -1,950 metres a.s.l., with temperatures ranging from 60 to 90 °C.

However, the region from the northern part of Cottbusser Ostsee towards the southern area of Guben City (Figure 6.4) is undisturbed by fault zones and exhibits a consistent thickness of around 400 metres at depths ranging from -1,000 to -1,400 metres a.s.l.

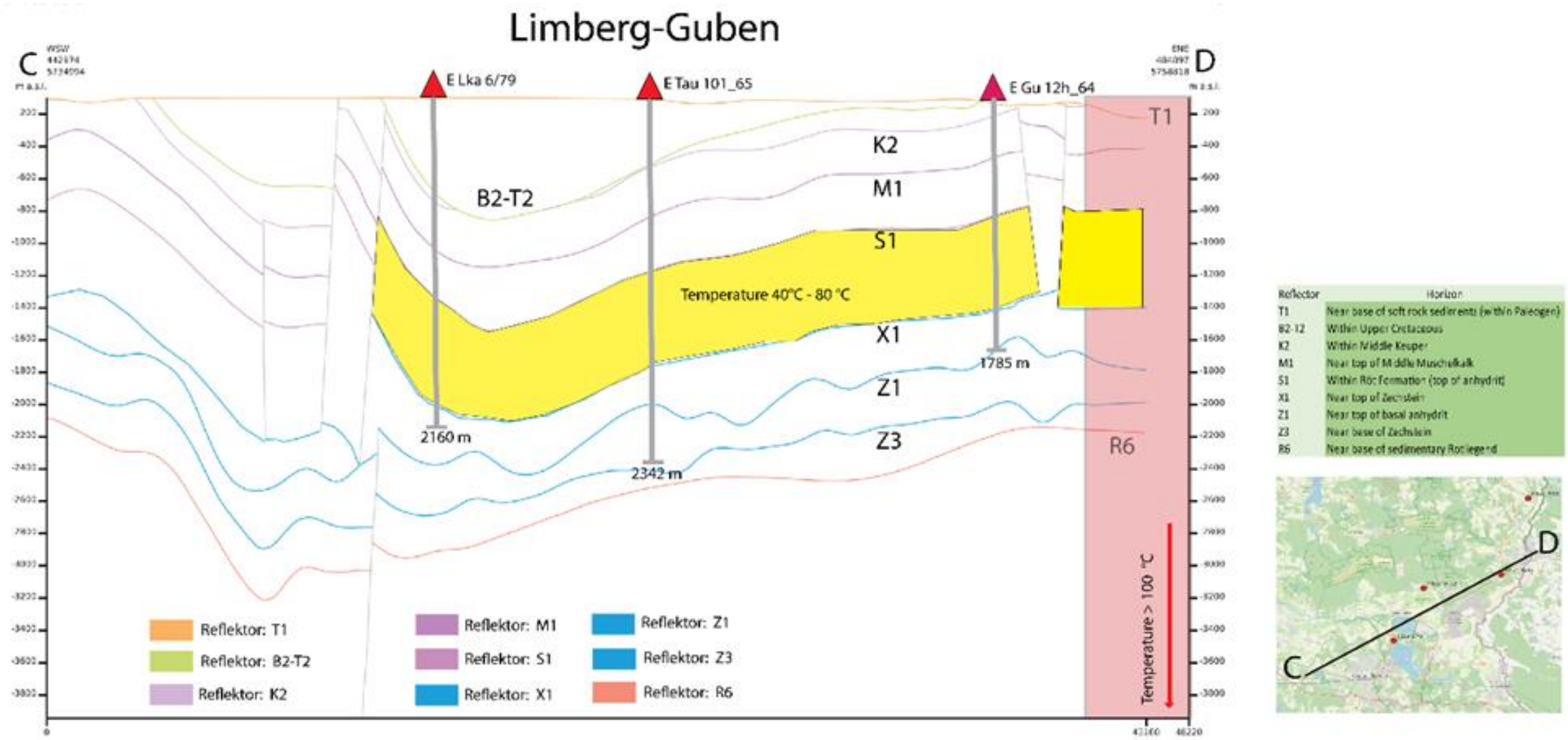


Figure 6.1: Limberg-Guben area is shown as a cross-section from the 3D Brandenburg model. Source: https://gst.brandenburg.de/. (Accessed October, 2025).

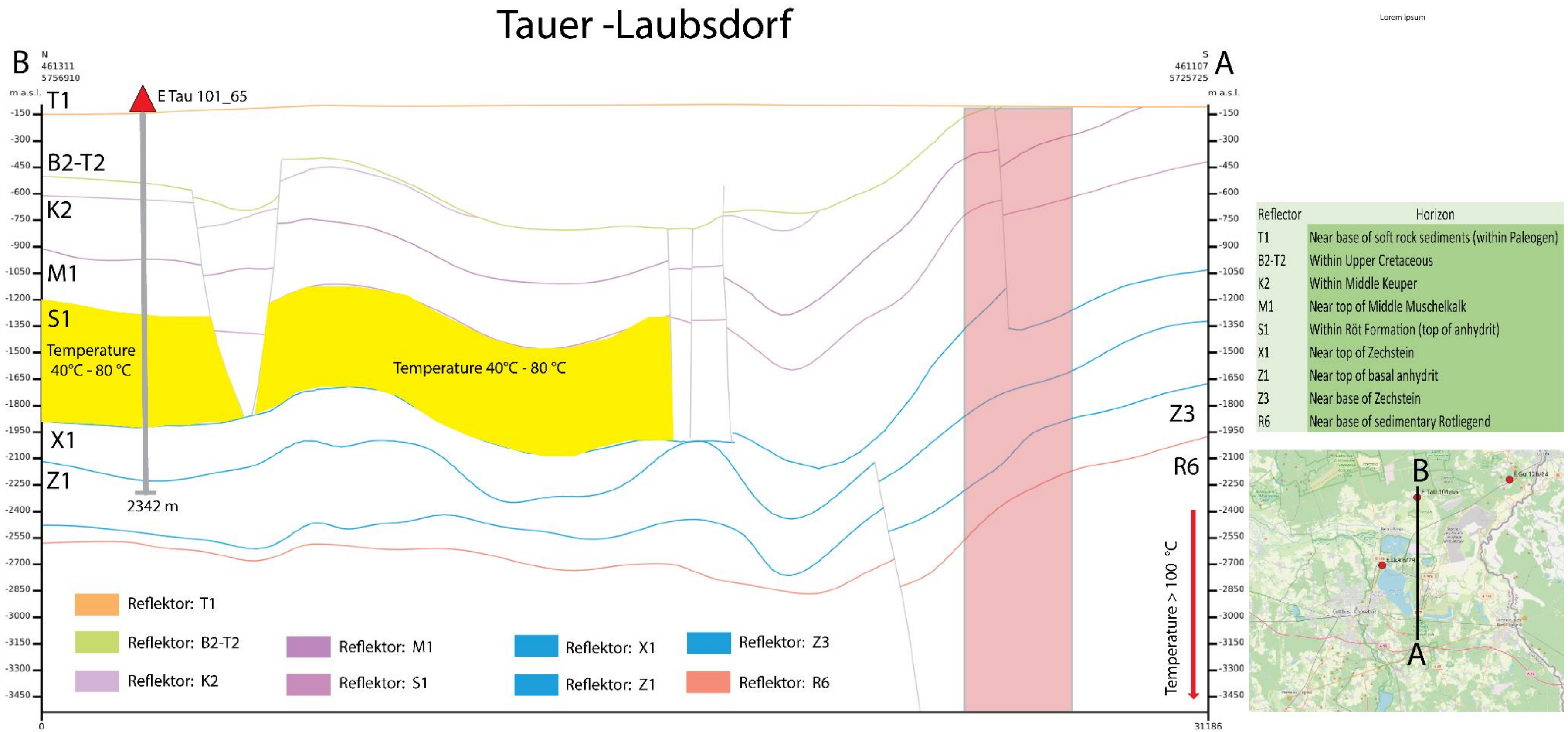
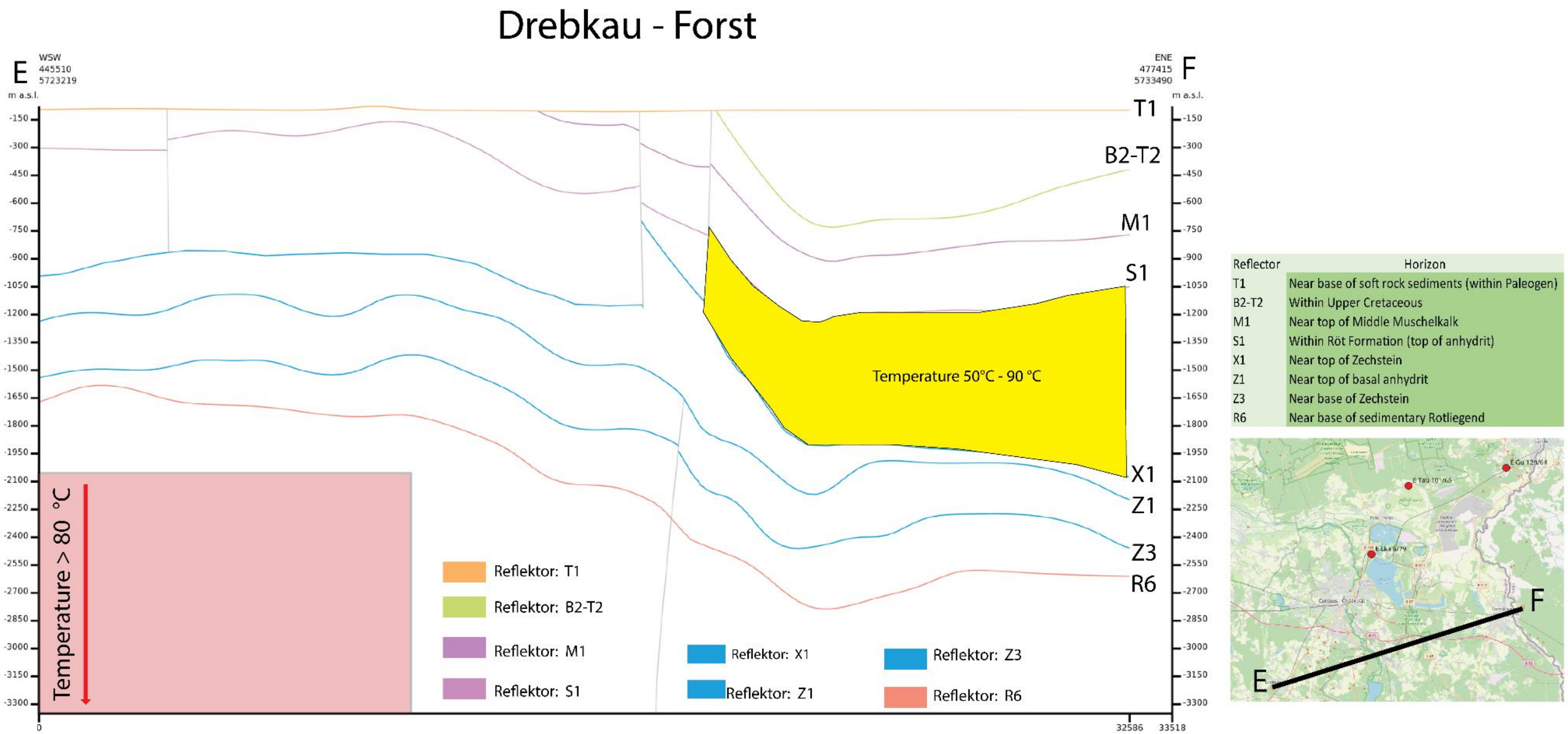
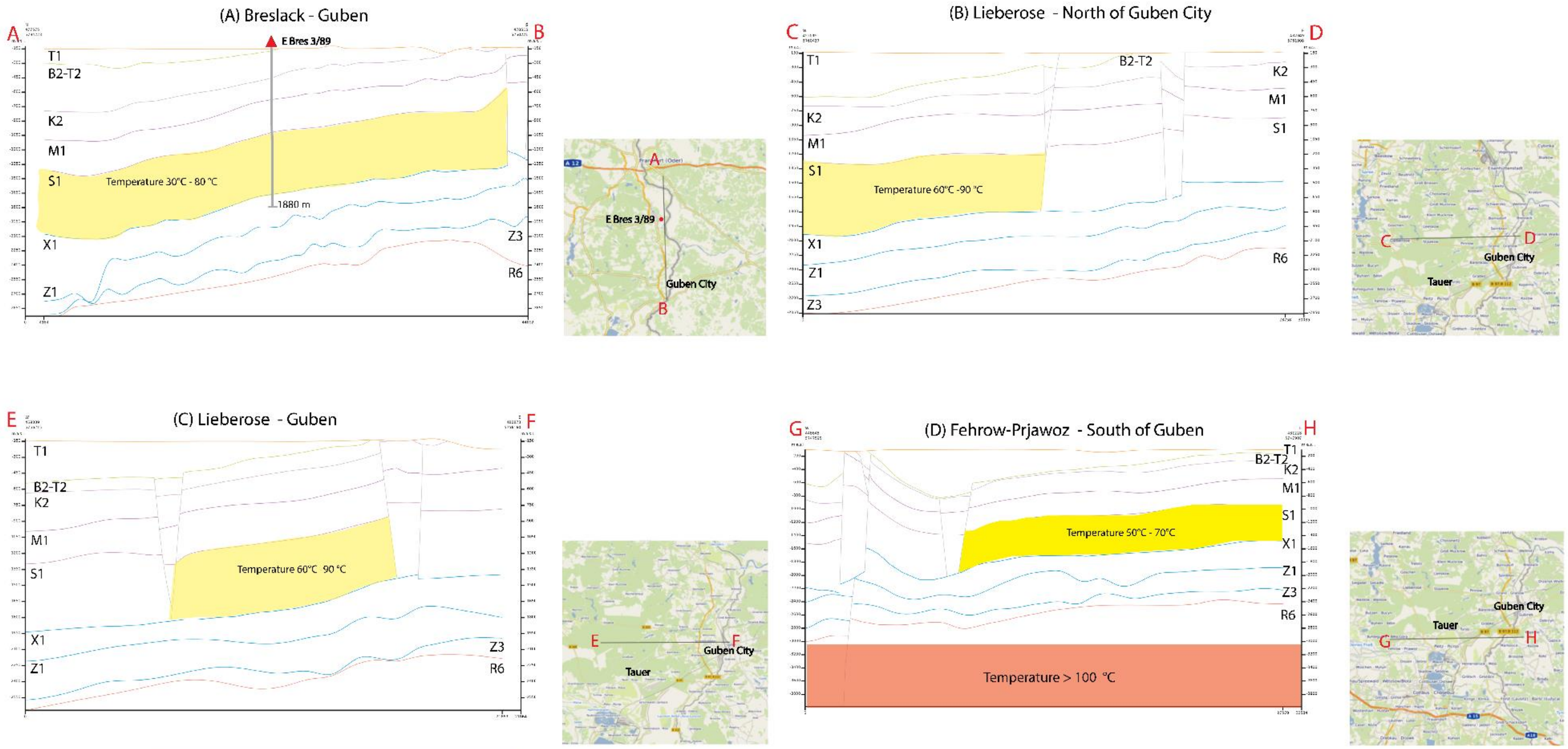


Figure 6.2: Tauer-Laubsdorf area area is shown as a cross-section from the 3D Brandenburg model. Source: https://gst.brandenburg.de/. (Accessed October, 2025).



Reflector	Horizon
T1	Near base of soft rock sediments (within Paleogen)
B2-T2	Within Upper Cretaceous
M1	Near top of Middle Muschelkalk
S1	Within Röt Formation (top of anhydrit)
X1	Near top of Zechstein
Z1	Near top of basal anhydrit
Z3	Near base of Zechstein
R6	Near base of sedimentary Rotliegend

Figure 6.3: Drebkau - Forst area is shown as a cross-section from the 3D Brandenburg model. Source: https://gst.brandenburg.de/. (Accessed October, 2025).



Reflector	Horizon
T1	Near base of soft rock sediments (within Paleogen)
B2-T2	Within Upper Cretaceous
K2	Within Middle Keuper
M1	Near top of Middle Muschelkalk
S1	Within Röt Formation (top of anhydrit)
X1	Near top of Zechstein
Z1	Near top of basal anhydrit
Z3	Near base of Zechstein
R6	Near base of sedimentary Rotliegend

Figure 6.4: Guben area is shown as a cross-section from the 3D Brandenburg model. Source: https://gst.brandenburg.de/. (Accessed October, 2025).

6.2 Summary of promising horizons for thermal energy storage

6.2.1 ATES

The success of Thermal Energy Storage (ATES) depends on the complex interplay of geological, hydraulic and chemical characteristics. Preferred aquifers consist of unconsolidated materials such as sand and gravel, though fractured rock can also be used, albeit with caution. Importantly, confined aquifers offer significant advantages over unconfined ones due to reduced heat loss and superior containment of the stored thermal energy. Achievable temperatures are directly correlated with depth; low-temperature ATES (below 30°C) has fewer depth requirements which have been widely applied in Netherland, whereas high-temperature systems (above 60°C) require depths of at least 300 metres to access sufficient geothermal gradients. The thickness and geometry of the aquifer must be balanced: thinner layers minimise tilting, but increase heat loss to the surrounding strata. Optimal well spacing, dictated by the ratio of well screen length to thermal radius (approximately 2), minimises this loss.

Beyond physical structure, strong hydraulic properties are paramount. High hydraulic conductivity (greater than 10^{-5} m/s) is essential for efficient water exchange, and transmissivity is a key economic driver, with an economically viable minimum threshold of around 5×10^{-13} m^3. The storage coefficient dictates the overall capacity and a low natural groundwater gradient is highly beneficial as it impacts the direction and rate of thermal breakthrough. High porosity further enhances storage efficiency and minimises conductive heat losses. However, favourable geology alone is not enough; careful assessment of water chemistry is also critical to prevent problems such as clogging due to fine particles, bacterial growth and scaling caused by minerals such as iron, manganese, calcium carbonate or gypsum. Solutions to these problems include gravel packs, chlorination or chemical treatments. Corrosion of well components must also be mitigated through material selection, cathodic protection or protective coatings. Finally, the strategic spacing and configuration of wells (around 1.8 times the thermal radius for high-temperature systems and potentially wider for low-temperature systems) are crucial for optimising pressure distribution and thermal interactions, and ultimately maximising the efficiency and longevity of the ATES system. There is no 'ideal' aquifer, and successful implementation demands careful consideration of these interconnected factors.

6.2.2 BHE and BTES

Fundamentally, both BHE (Borehole Heat Exchanger) and BTES (Borehole Thermal Energy Storage) systems share similar underlying reservoir parameters for effective operation. Both rely on favourable subsurface conditions – high thermal conductivity and specific heat capacity of the surrounding rock, and very low permeability – to efficiently transfer heat, whether extracting geothermal energy (BHE) or storing thermal energy for later use (BTES). The thermal properties of the rock mass dictate the overall system performance, influencing heat extraction/storage rates, temperature drawdown/build-up, and the required well spacing. While DBHE focuses on accessing naturally occurring geothermal gradients, and BTES relies on cyclical charging and discharging, the fundamental requirement for a thermally conductive and capacious subsurface reservoir remains consistent. The choice of working fluid and well design (including tube configurations and insulation) aims to optimize heat transfer between the borehole and the surrounding rock in both systems.

However, a key distinction lies in system scale and operational strategy. DBHE systems can often function as standalone heat sources, while BTES networks require a larger array of boreholes to achieve the necessary thermal storage capacity and deliver consistent heat or cooling output. This difference dictates the importance of assessing the spatial extent and homogeneity of the reservoir – crucial for BTES to ensure even thermal distribution and prevent short-circuiting between injection and production wells. Ultimately, understanding the reservoir’s thermal properties and flow characteristics is paramount for both DBHE and

BTES, influencing well placement, system design, and long-term operational efficiency. For DBHE, these parameters determine the sustainable heat extraction rate; for BTES, they dictate the storage capacity and discharge performance.

6.3 Depth, temperature, and average thickness of the most promising aquifers for ATES and BHE or BTES

Table 6.1 summarizes the current identification on the potential reservoir that is suitable for ATES and BHE or BTES.

Potential area	ATES			BHE/BTES		
	Potential reservoir	Depth (m.b.s.l) / Thickness	Temperature (°C)	Potential reservoir	Depth (m.b.s.l)/ Thickness	Temperature (°C)
Limberg-Guben area	Lower and Middle-Buntsandstein	800 - 2100 / 600	40 - 80	Zechstein - Rotliegend (basement) at Guben part	2000 - 3000 (> 3000)	> 90
Tauer-Laubsdorf area	Lower and Middle-Buntsandstein	1200 - 2000/ 650	40 - 80	Zechstein - Rotliegend (basement) at Laubsdorf area	1800 - 3000 (> 3000)	> 90
Drebkau-Forst area	Lower and Middle-Buntsandstein	750 - 2000/ 500	50 - 90	Zechstein-Rotliegend (basement) at Drebkau area	1200 - 3000 (>3000)	> 90
Guben area	Lower and Middle-Buntsandstein	600 - 2000/ 600	30 - 80	Zechstein-Rotliegend (basement)	1400 - 3000 (> 3000)	> 70

Table 6.1: Summary of potential locations for UTES application.

6.3 Exploration strategy in the region

6.3.1 Result on the current geological assessment

The regional geothermal exploration strategy leverages existing infrastructure to minimize costs and utilize the established energy network. Geological assessments indicate promising subsurface storage potential within the Middle Buntsandstein formation, a key regional geological feature. Storage capacity is dependent on its permeability and porosity. The Middle Buntsandstein with economically promising Volpriehausen horizon, identified as a potential aquifer within this formation, is currently under investigation in the Cottbus and Guben areas.

The Lausitz region offers advantages for efficient, high-temperature thermal storage due to its location at the basin's edge. Areas with shallow basement exposure and thin sediment cover are particularly well-suited for Borehole Heat Exchanger (BHE) and Borehole Thermal Energy Storage (BTES) systems. Potential locations have been identified south of Cottbus and Guben, offering a localized, sustainable energy source.

In areas with basement exposed near to the surface area with particularly thin sediment layers, Enhanced Geothermal Systems (EGS) may be viable, tapping into the Rotliegend and Lausitz basement formations (at a depth of more than 3,000 m b.s.l) with temperatures exceeding 100°C. This could provide a long-term, base-load renewable energy option.

Current assessments are based on qualitative geological data. Further investigation is needed to refine these findings and accurately delineate the Volpriehausen horizon within the Middle Buntsandstein. This includes taking precise seismic measurements and carrying out a detailed analysis to determine the depth of the Lausitz basement. Furthermore, interpreting the localised structures would be significantly improved by seismic data, which would allow the precise measurement of the reservoir volume and distribution. The existing E Tau 101/65 well, located in an area with fully developed infrastructure at a depth of 2,342 m b.s.l, currently only reaches the Staßfurt-Haupdolomit formation. Future surveys are essential to pinpoint optimal drilling locations and assess the full potential of these storage horizons.

6.3.2 Seismic campaign in Lausitz area

The Brandenburg Ministry of Economic Affairs has commissioned the Landesamt für Bergbau, Geologie und Rohstoffe (LBGR) to conduct an initial seismic survey of Lower Lusatia, as announced by the LBGR. This will involve examining the subsurface from a geothermal perspective. The results will provide local authorities, industry and project developers with a better basis for planning, thereby reducing investment risks. One way to reduce uncertainty, particularly when selecting locations for further drilling based on the suitability of the geothermal application, is to take precise measurements of 2D seismic data. The location of the seismic survey is shown in **Figure 6.5**. The seismic line is marked by an orange line in the relevant figure. The current feasibility study supports the area proposed for the seismic survey, which aligns with the area under consideration between Cottbus and Guben. When evaluating the potential application of geothermal energy in the Lausitz area, the results of the seismic survey would justify progressing to the next stage of quantifying the potential of the geothermal resources and the initial investment required to develop geothermal energy in the region.

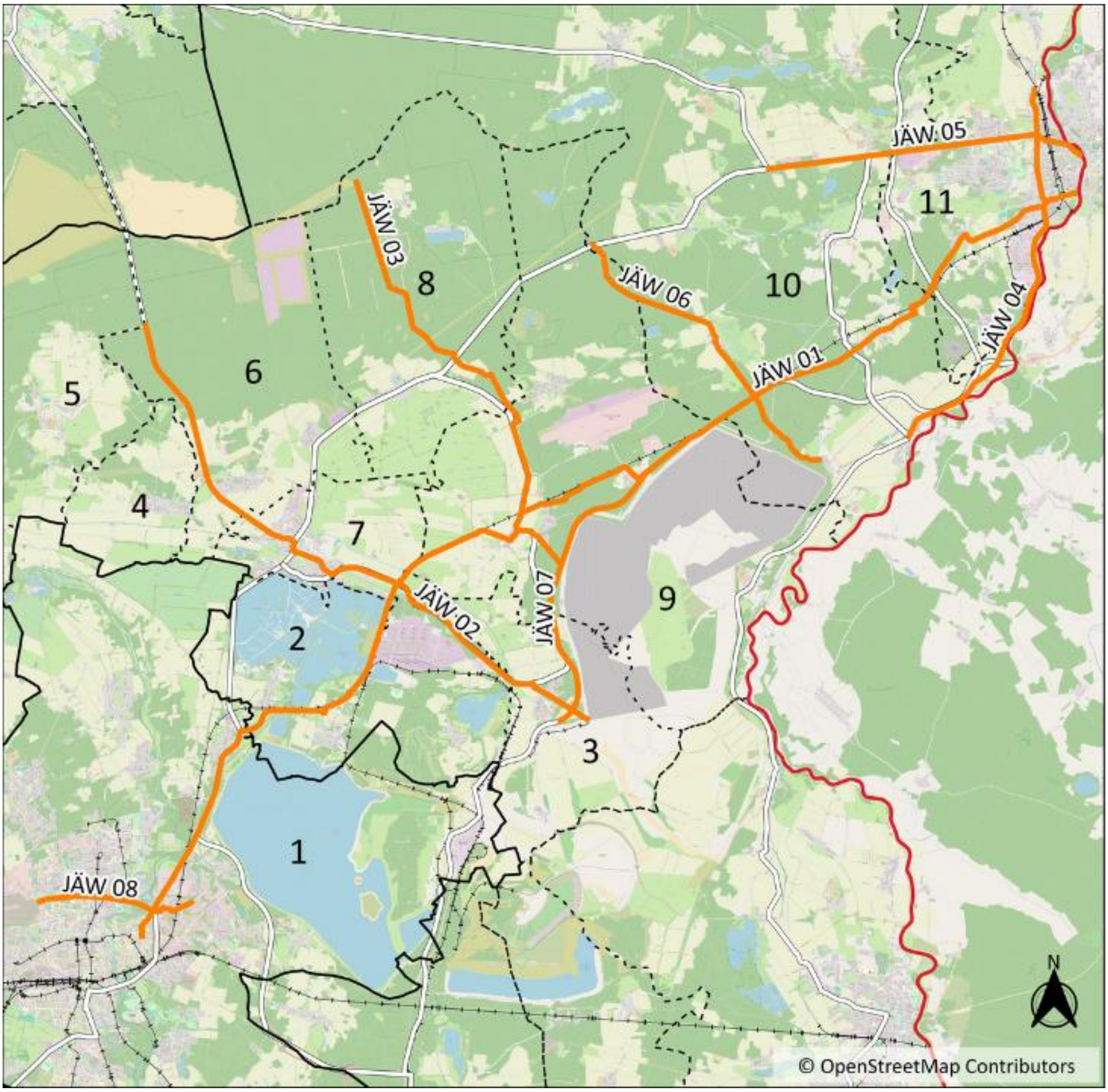


Figure 6.5: Location of 2D Seismic Campaign conducted on October 2025. (1) Cottbus; (2) Teichland; (3) Heinersbrück; (4) Drehnow; (5) Dachhausen; (6) Turnow – Preilack; (7) Peitz; (8) Tauer; (9) Jänschwalde; (10) Schenkendöbern; (11) Guben. Source: https://lbgr.brandenburg.de/lbgr/de/aktuell/2d-seismische-kampagne/. (Accessed October, 2025).

7. Conclusion

In the current state of affairs, leveraging the current infrastructure to fulfil the heating demand makes thermal energy storage a highly important option that needs to be prioritised. **Figure 7.1** shows the next focus area for geothermal applications in the Lausitz region.

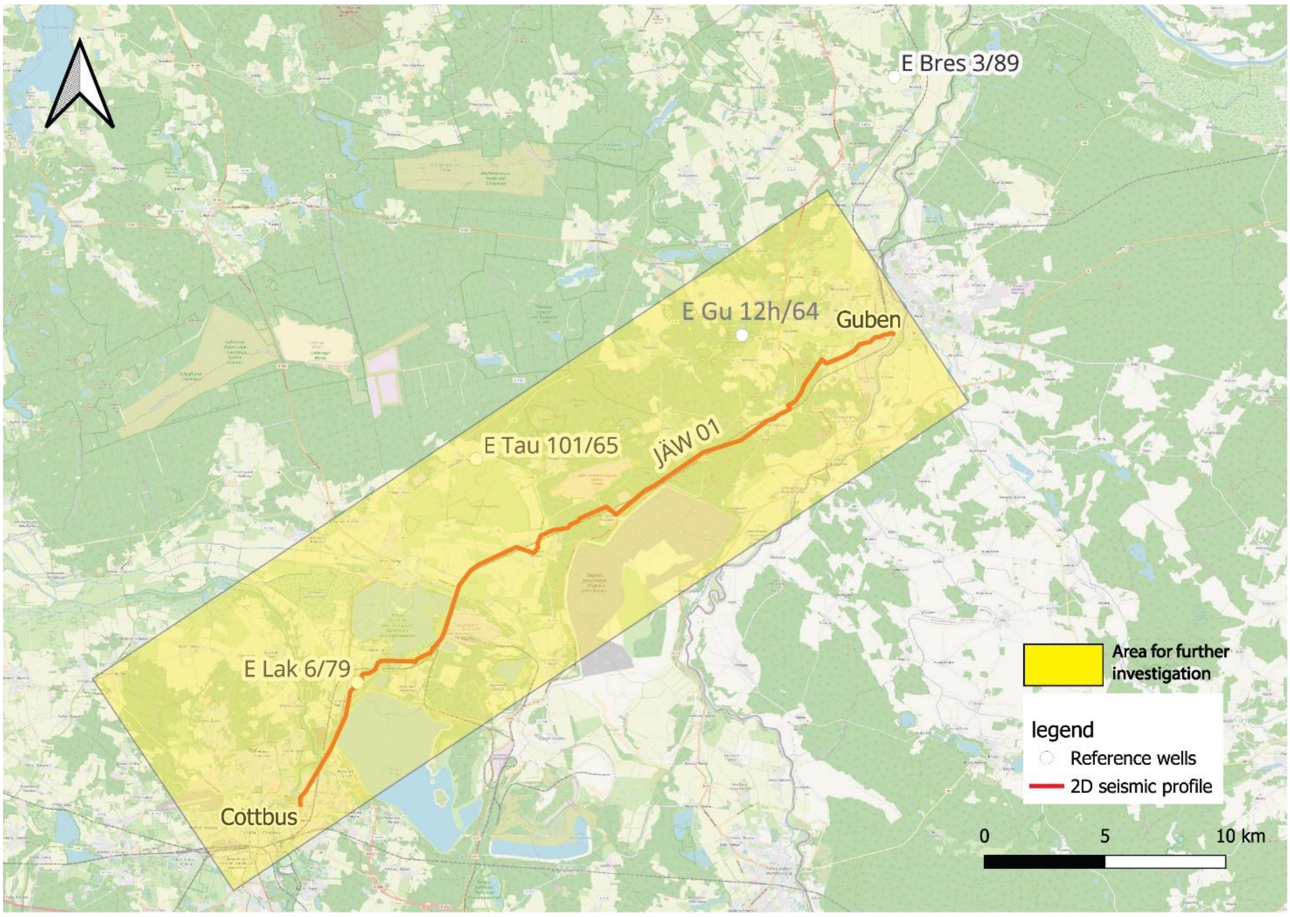


Figure 7.1 Potential area for thermal storage application between Cottbus and Guben cities. Source: https://www.openstreetmap.de/karte/#. (Accessed October, 2025).

Based on the current pre-feasibility study assessing the suitability of geothermal energy applications in the Lausitz region, the area has the potential to be used as an underground thermal storage site, supporting the transition of existing infrastructure to renewable energy production. Understanding the potential geothermal resources in the area, as well as reducing sub-surface uncertainty through the local government's seismic campaign, has shown immense support for encouraging sustainable energy provision in the region. This report provides a general overview of how the region's socio-economy can transition to a sustainable energy source, reflecting the demand for energy that drives the exploration of new energy sources, such as geothermal energy.

The way forward with the current ongoing exploration is that, once sub-surface data has been acquired, the location and depth of the potential reservoir can be determined with certainty. These results would enrich our understanding of the reservoir's depth, distribution and volume. From this point onwards, the storage potential can be evaluated through reservoir modelling, as well as determining suitable locations for exploration drilling, which is particularly relevant for aquifer thermal energy storage, as more sub-surface validation is needed, such as certainty regarding the hydraulic parameters and the chemical characteristics of the reservoir fluid.

On the other hand, although the application of deep BHE and BTES is quite possible, it is most likely not an economical option as it requires new drilling. In this case, the application of the technology will be limited to existing open boreholes that offer economically feasibility. In the current exploration plan, this is an additional, locally identified potential linked to a private entity that possesses an active well and which will depend heavily on its business foresight.

As our understanding of the subsurface increases, EGS could be used to explore areas of the basement with temperatures higher than 100 °C. This would be long-term planning, assuming the technology becomes mature.

8. Appendix

Cost estimation of UTES (DBHE, BTES, ATES) and EGS technologies developed in TRANSGEO project in Deliverables D.1.2.1. The provided costs (**Table 8.1 and Table 8.2**) are based on the context of reusing existing wells. The need of new well needs to be considered for further use.

Technology	Workover	Service	Material	Total cost by technology
DBHE (1 x 2000 m)	330.000-350.000 €	45.000-50.000 €	150.000-160000 €	525.000 – 560.000 €
BTES (1 x 2000 m)	330.000-350.000 €	45.000-50.000 €	150.000-160000 €	525.000 – 560.000 €
ATES (1 x 2000 m)	240.000-260.000 €	45.000-50.000 €	50.000-60.000€	335.000 – 370.000 €
EGS (2 x 3000 m)	2.000.000-2.100.000 €	120.000-150.000 €	100.000-120.000 €	2.220.000 – 2.370.000 €

Table 8.1 Investment costs for workover intervention for DBHE, BTES, ATES, technologies according to the market prices in 2023/2024 in Austria and Germany (Appendices 1-5, questionnaires from partner countries). The values are estimated (Prkič et al., 2025)

Technology	Surface/ Downhole pumps	Piping installation	Heat Exchanger	Metering system	Total cost by technology
DBHE (1 x 2000 m)	10.000 - 15.000 €	15.000-20.000 €	15.000-20.000 €	10.000-15.000 €	50.000 - 70.000 €
BTES (1 x 2000 m)	10.000 - 15.000 €	15.000-20.000 €	15.000-20.000 €	10.000-15.000 €	50.000 - 70.000 €
ATES (1 x 2000 m)	25.000 - 30.000 €	15.000-20.000 €	15.000-20.000 €	10.000-15.000 €	65.000 - 85.000 €
EGS (2 x 3000 m)	180.000-220.000 €	400.000-500.000 €	150.000-500.000 €	60.000 - 80.000 €	790.000 – 1.300.000 €

Table 8.2 Investment cost for surface equipment required for DBHE, BTES, ATES, technologies according to the market prices in 2023/2024 in Austria and Germany (Appendices 1-5, questionnaires from partner countries). The values are estimated. (Prkič et al., 2025)

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