NEWSLETTER
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Baseline Conditions for Energy Storage in Post-Mining Shafts - Budryk III Shaft Case Study

Background and motivation

The energy transition increases the demand for large-scale energy storage technologies capable of supporting power system stability under a growing share of renewable energy sources. One of the promising options is compressed air energy storage (CAES), which may utilise existing post-mining infrastructure, including deep mine shafts. Before such infrastructure can be considered for high-pressure operation, its technical and geomechanical condition must be clearly assessed. Within the HESS project, a dedicated document defining *Baseline Conditions* was developed. The baseline establishes the minimum acceptable technical, structural and geomechanical state of a mine shaft that allows it to be considered for further analysis in the context of CAES. It does not constitute a system design or optimisation study, but rather provides a technical screening framework separating potentially suitable shafts from those that should be excluded for safety or durability reasons.

Selection of the reference shaft

The definition of baseline conditions required the selection of a representative reference object. This selection was supported by a multi-criteria decision analysis (MCDA), which considered shaft geometry, structural characteristics, operational function, accessibility and adaptation potential. Based on this analysis, the Budryk III shaft was selected as the reference shaft. It is a hoisting, man-riding and ventilation shaft of strategic importance to the mine, characterised by a massive lining structure and favourable geometric parameters. These features make it a representative example of high-standard post-mining infrastructure suitable for defining baseline requirements. The geographical location of the reference shaft is presented in Figure 1.

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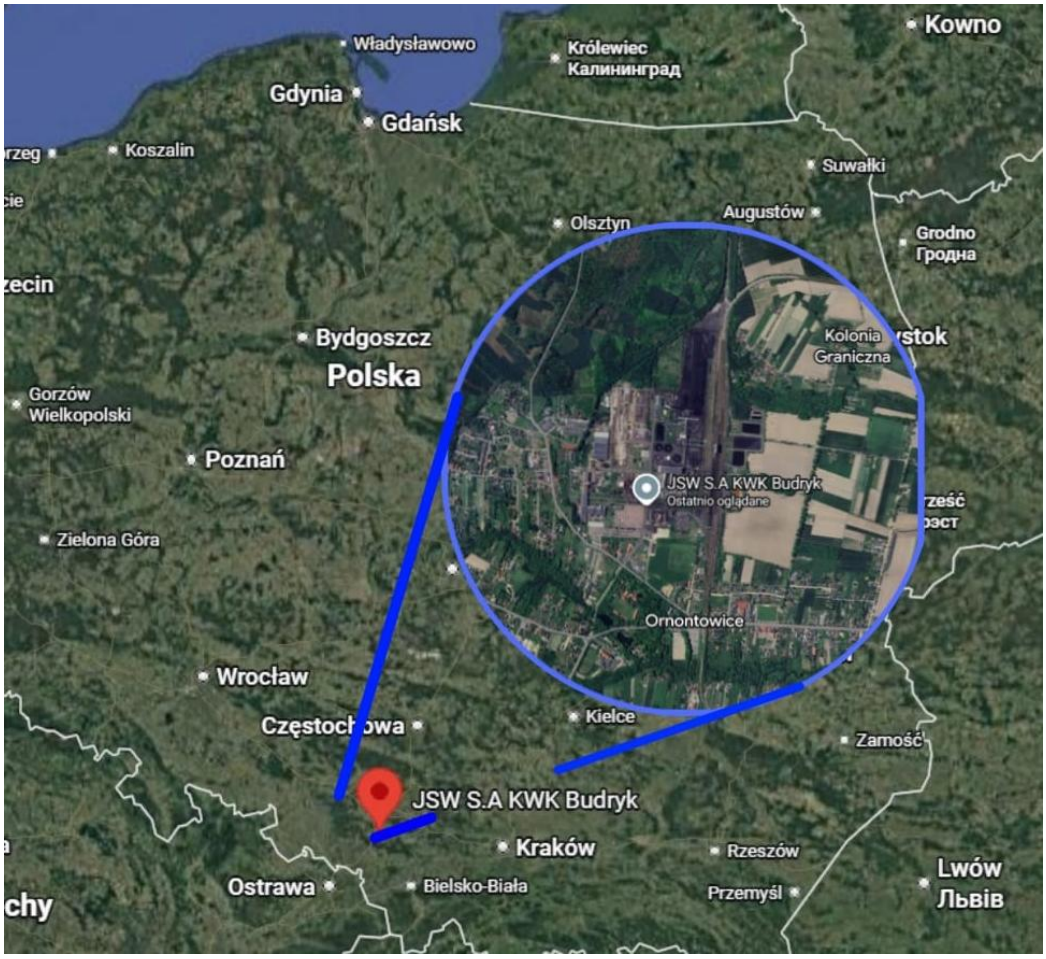

Figure 1 Location of the Budryk III shaft in Poland.

Integration of previous analyses into baseline conditions

The Baseline Conditions are based on the integration of results obtained in earlier stages of the project. The MCDA-based preselection was followed by advanced analytical and numerical investigations of shaft behaviour under pressurised conditions. These analyses addressed the response of the shaft lining and surrounding rock mass to elevated internal pressure and allowed the identification of parameters critical to safe operation.

The outcomes were translated into engineering guidelines defining admissible ranges of geometric, structural and geomechanical parameters that collectively determine whether a shaft may be considered technically suitable for compressed air storage.

Structural stability and the role of the sealing plug

The analyses demonstrated that, for the assumed operating pressure of up to 8 MPa, the shaft lining remains stable throughout the active storage section. Potentially unfavourable stress conditions may occur only within the shallow near-surface zone.

This observation does not limit the applicability of the concept, as in CAES systems the upper part of the shaft is, by definition, excluded from pressurised operation. The construction of a massive reinforced concrete sealing plug in the upper section of the shaft is therefore not a remedial measure addressing local structural deficiencies, but an inherent element of the high-pressure storage concept. The sealing plug ensures system tightness and isolates the active storage volume from near-surface zones that do not provide sufficient geomechanical confinement.

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Influence of geological discontinuities

Additional analytical and numerical studies examined the potential influence of geological discontinuities, such as faults and fracture zones. The results indicate the stress and structural conditions under which such features may affect shaft stability. This provides practical guidance on when simplified analytical approaches are sufficient and when more advanced numerical modelling is required during further stages of assessment.

Role of baseline conditions within the project

The Baseline Conditions established in this work form a technical reference framework for subsequent activities within WP4. They define the boundary conditions for further modelling, material testing and adaptation concepts, ensuring consistency between theoretical assumptions, safety requirements and the actual condition of post-mining infrastructure considered for energy storage applications.

The work resulted in deliverable ***D.4.2 Guidelines for the baseline condition of the reference shafts***

We invite you to explore more details of the work on the HESS project website https://itpe.pl/en/hess/

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