

Holistic Methodology for Circular Decommissioning of Abandoned Mines and Coal-fired Plants using Gravity Energy Storage

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OVERVIEW

GRAVITEQA develops a holistic methodology for the circular decommissioning of abandoned mines and coal-fired power plants through the deployment of large-scale **Gravity Energy Storage (GES)**. The methodology determines the optimal storage technology and sizing for a given decommissioned site and is structured in three stages: (a) **capacity estimation** from the site's infrastructure (shafts, hoisting systems, buildings); (b) **financial assessment** covering capital and operational expenditures and revenues from electricity-market participation; and (c) **operational optimisation** of the storage system. Two configurations are developed and verified with example results — the **Shaft-GES** (vertical shafts of mines and plants) and the **Piston-GES** — together with **hybrid operation with Pumped Hydro Storage**. The project's life-cycle and technoeconomic assessment complements the design: reusing existing infrastructure cuts construction emissions by 80.75% (Shaft-GES) and 49.75% (Piston-GES), and iron emerges as the most promising suspended-mass material.

BENEFITS

- **Circularity:** repurposing stranded coal assets avoids demolition waste and new-build impacts — up to ~81% lower construction-phase CO₂eq (reuse vs new-build, Shaft-GES).
- **Long-duration storage for RES integration:** converts decommissioned sites into grid-scale assets supporting reliability of clean-transition grids.
- **Revenue-aware design:** sizing is co-optimised with day-ahead market participation, linking technical design to financial viability.
- **Material guidance:** comparative analysis (cement, iron, steel; iron vs lead pistons) steers cost-effective engineering choices.

CURRENT ENABLERS

- EU coal phase-out pipeline providing candidate sites (mines and plants) for retrofitting; pilot access via PPC.
- Requirements, use cases and KPIs defined in the project's requirements-engineering phase (optimal design and sizing of storage on abandoned power-plant assets).
- Project LCA/LCC evidence base (life-cycle inventories, cost libraries, market price data).
- Circular Economy Action Plan and just-transition policy momentum.

R&D NEEDS / NEXT DEVELOPMENTS

- **Additional GES configurations:** mountain mine-car GES systems for inclined mining structures.
- **Multi-market participation:** extending from single day-ahead market to simultaneous participation including the balancing energy market.
- **Hybridisation:** combining long-duration GES with high-power, fast-response storage (Shaft-GES + flywheel).
- **Circular-economy accounting:** incorporating cost savings from repurposing abandoned infrastructure into the financial models.
- **Validation** of the methodology on the project pilot sites against the project KPI framework.

APPLICATIONS

- **Plant owners & utilities:** investment decision support for decommissioned coal plants and mines.
- **Technology developers:** reference design and sizing workflows for Shaft- and Piston-GES.
- **System operators:** long-duration storage capacity supporting adequacy and flexibility.
- **Policy makers / regions:** quantified circularity benefits for just-transition planning.

TECHNOLOGY READINESS LEVEL

1	2	3	4	5	6	7	8	9
■ Current level	■ After validation							
TRL 3 currently (methodology and alpha models verified on example cases); TRL 4 to be reached upon completion of the validation on the project pilot sites.								